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THE HAWAIIAN PLANTERS' RECORD

Volume XXIX. JANUARY, 1925 Number 1

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Variety Areas

Statistics now being compiled show the area of H 109 for the 1925 and 1926 crops to be about 78,000 acres. This almost equals the area of Yellow Caledonia which has dropped to about 80,000 acres for the two crops in question.

There are now less than 6,000 acres of Lahaina.

The area of D 1135 is now about 35,000 acres, an increase of about 5,000 acres since a year ago.

The increase in H 109 in a year's time amounts to 12,000 acres.

The reduction in the area of Yellow Caledonia is nearly 10,000 acres.

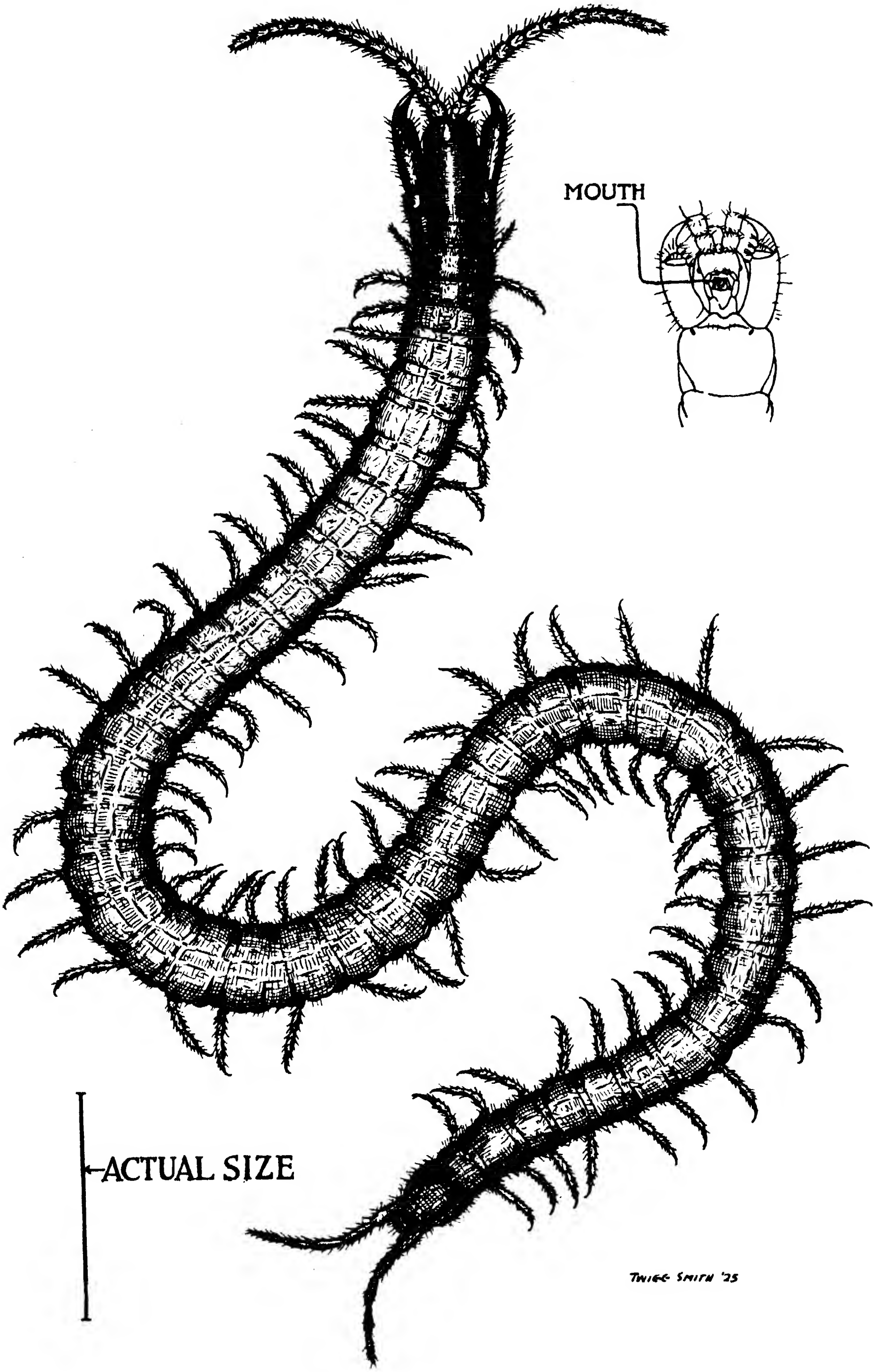
The Early History of D 1135

The cane variety D 1135 was imported into Hawaii from Queensland about 1901 or 1902. We have written to Australia and to Demerara for the early history of this variety.

Mr. C. Ernest Young, of Fairymead Sugar Company, Limited, of Bundaberg, Queensland, tells us that D 1135 was imported by his plantation from Demerara in 1895 with other seedlings from Barbados, Trinidad and Demerara.

Sir John B. Harrison, of Georgetown, British Guiana, confirms this in saying that his records show that D 1135 with some fifty other sorts was sent at the request of Sir Neville Lubbock to Queensland in 1895.

D 1135 was raised in 1892 by G. S. Jenman and Sir John B. Harrison. D 1135 was a seedling of D 103, and the latter is thought to be a seedling from a cane known as Caledonian Queen, presumably a strain of White Transparent.



Mecistocephalus maxillaris

Specimens of this centipede were sent by P. H. Timberlake to R. V. Chamberlain, of the Museum of Comparative Zoology, Cambridge, Mass., for identification in August, 1922. In reply, Mr. Chamberlain gave the identification as above, stating that the "species is widespread in the warmer parts of this Hemisphere, being particularly common in South America and the West Indies," occurring also "at various places in Polynesia and has previously been recorded from Hawaii."

Cane Root Injury by the Centipede, *Mecistocephalus maxillaris*

By C. E. Pemberton

Since my original belief in 1922 that the soil-inhabiting centipede, *Mecistocephalus maxillaris*, was responsible for a great deal of the root hole injury appearing on the roots of cane in Hamakua and Kohala, I have periodically made small experiments to further verify the contention, together with frequent examinations of roots in the field. The experiments were never very satisfactory, my time was mostly occupied in other work and I have always felt that the original work needed some confirmation before this centipede could be considered of any real importance.

I have always experienced difficulty in growing cane roots in culture, having vigor and size comparable with roots growing in the field. Small, weak roots springing from the seed-piece do not appear acceptable. Repeated failures, when using such roots in culture, often led me to believe that the centipedes only rarely attacked them. Mr. McGeorge's paper in the July, 1924, *Record*, describing similar difficulties and explaining his solution of the trouble by growing only roots springing from shoots and not borne by the fermenting seed-piece, also solved my difficulty. I have planted "lalas," or shoots, which were entirely removed from the stick on which they grew. Roots from these have been satisfactory.

In a total of 30 tests in sterile soil, using 260 centipedes all told, and 342 roots, 152 holes and lacerations have appeared on the roots, these being in the soil with the centipedes from 1 to 4 days only, except No. 12, which lasted twelve days. These root wounds are identical in their varied shapes and sizes with those appearing on cane roots in the field.

The separate experiments were as follows:

(1) One adult centipede placed in glass jar filled with sterile soil September 22, 1924, in which one cane root 1½ inches long was inserted, the root being from sterile sand where it was grown. In 24 hours the root was removed. The growing tip was eaten out and 2 large irregular holes, penetrating well into the central cylinder, had been made. These holes, about 2 mm. in diameter, occurred on the last half-inch of the root.

(2) One adult centipede placed in glass jar filled with sterile soil September 28, in which 4 sound cane roots, each about 2 inches long, were inserted, the roots having been grown in sterile sand. The roots were removed and examined 18 hours later. The growing tips of three of the roots were completely destroyed. The fourth root was untouched.

(3) One adult centipede placed in glass jar filled with sterile soil September 29, in which 2 sound cane roots, previously grown in sterile sand, were placed. Upon examination 24 hours later, the growing tip of one root had been completely eaten out. The other root remained sound.

(4) One adult centipede placed in glass jar filled with sterile soil September 29, in which 1 sound cane root, grown in sterile sand, was inserted. Examined 24 hours later. The growing tip had been hollowed out.

(5) One adult centipede placed in glass jar filled with sterile soil September 30, in which 1 sound sand-grown root was inserted. Two hours later, upon examination, the growing tip was completely hollowed out. In this instance, the centipede could be observed working on the root, which lay in the soil next to the glass.

(6) One adult centipede placed in glass jar filled with sterile soil October 2, in which 2 sound cane roots, grown in sterile sand, were inserted. Upon examination 24 hours later, each root had the growing tip completely hollowed out.

(7) One adult centipede placed in glass jar filled with sterile soil October 3, in which 3 sound cane roots, grown in sterile sand, were inserted. Half an hour later, the centipede was observed with its head well into the growing tip of one root, the root lying next to the glass.

(8) Five young centipedes placed in glass jar filled with sterile soil October 7, in which 4 sound sand-grown roots were inserted. Upon examination 24 hours later, 2 roots each had 1 small, deep, circular hole through the cortex near the tip.

(9) Three young centipedes placed in glass jar of sterile soil October 11, in which four sound sand-grown roots were inserted. Upon examination October 13, two of the roots each had one small circular hole into cortex near end.

(10) One young centipede placed in glass jar of sterile soil October 11, in which 5 vigorous sand-grown sound roots were inserted. Upon examination October 13, one root had one small circular hole through cortex near tip. The other roots were sound.

(11) One adult centipede placed in glass jar of sterile soil October 11, in which 5 sound sand-grown cane roots were inserted. Upon examination October 15, the growing tips of two of the roots were completely destroyed. The other roots remained sound.

(12) One adult centipede placed in glass jar of sterile soil October 11, in which a cane seed-piece, bearing 9 sound sand-grown roots, was placed. Examined October 15. The growing tips of two of the roots were completely destroyed and another root was almost eaten in half one-fourth inch from tip. The other roots remained sound.

(13) One adult centipede placed in glass jar of sterile soil October 20, in which 2 sound sterile soil-grown cane roots were placed. Examined October 22. The entire end of one root was consumed for a distance of one-eighth inch and the other root was eaten into and almost severed one-fourth inch from tip.

(14) Eight young centipedes placed in jar of sterile soil October 20, in which 2 sound sterile soil-grown cane roots were placed. Examined October 22. One fairly large circular hole in 1 root one-fourth inch from end and 1 small circular hole in other root one-half inch from base.

(15) Eight young centipedes placed in glass jar of sterile soil October 20, in which 2 sound sterile soil-grown cane roots were inserted. Examined Octo-

ber 22. Only 1 centipede remaining alive. One small oval hole in one root through cortex, marking surface of central cylinder, one-fourth inch from base.

(16) One adult centipede placed in glass jar of sterile soil October 22, in which 2 sound, sterile soil-grown roots were inserted. Examined October 23. The end of 1 root was destroyed for one-fourth inch; only a few threads of fiber left at end. Other root untouched.

(17) Eight young centipedes placed in glass jar of sterile soil October 22, in which 3 sound, sterile soil-grown cane roots were inserted. Examined October 24. The tips of all 3 roots hollowed out. One root also had 1 small, circular hole through cortex one and one-half inches from tip, and another small, circular hole through cortex two inches from tip.

(18) Eight young centipedes placed in glass jar of sterile soil October 25, in which 6 sound sand-grown cane roots were inserted. Examined October 27. Two roots each had 1 small, circular hole through cortex one-eighth inch from end. The other roots were sound.

(19) Eight young centipedes placed in glass jar of sterile soil October 25, in which 3 sound sand-grown cane roots were inserted. Examined October 27. One root had one small circular hole through cortex one-fourth inch from end, and a circular hole 1 mm. in diameter through cortex one-half inch from end. The second root had 1 circular hole 1 mm. in diameter through cortex one-fourth inch from end. The third root had 1 small circular hole through cortex one-fourth inch from end.

(20) Eight young centipedes placed in glass jar of sterile soil October 25, in which 2 sound sterile soil-grown roots were inserted. Examined October 27. One root had 5 small, circular holes, well into cortex, one-half mm. in diameter, all from one-fourth to one inch from tip. The other root was untouched. It was not so vigorous a root when inserted in the jar.

(21) Two adult centipedes placed in glass jar of sterile soil October 25, in which 6 sound sand-grown cane roots were inserted. Examined October 27. One root had tip badly lacerated and a large jagged hole through cortex into central cylinder one-fourth inch from tip. No injury to other roots.

(22) Twenty young centipedes placed in glass jar of sterile soil October 28, in which 7 sound sand-grown cane roots were inserted. Examined October 31. One root had 3 small, circular holes through cortex within one-fourth inch of end, one root had 1 small, circular hole through cortex one-eighth inch from end, and one root had one small, circular hole through cortex one-fourth inch from end. Roots not vigorous.

(23) Ten young centipedes placed in glass jar of sterile soil November 4, in which one cane eye with roots just starting was inserted. Examined on November 8. Of 42 roots, which had reached lengths varying from one-fourth inch to two inches, 10 each contained one small, circular hole from one-fourth to 1 inch from end.

(24) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 38 roots present, which had grown to lengths of one-fourth to two and one-half inches, 5 each had 1 small, circular hole through cortex near tips.

(25) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 58 roots present, varying in length from one-fourth to two inches in length, 7 each had 1 small, circular hole through cortex near tip.

(26) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 35 roots present, varying in length from one-fourth to two and one-half inches, 4 each had 1 small, circular hole through cortex near tip, and a fifth root had 2 small, circular holes through cortex near tip.

(27) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 45 roots present, varying in length from one-fourth to three inches, 5 each had 1 small, circular hole through cortex near tip.

(28) Thirty young centipedes placed in wooden box 10 x 6 x 6 inches, filled with sterile soil November 8, in which 3 lalas or cane shoots were planted. None of the cane stick itself being attached excepting a very small bit for support at the bases of the shoots. Examined November 14. Fifteen roots, all vigorous, had grown out from one to three inches in length. A total of 18 small circular holes, mostly through cortex, were counted on 11 of the roots. Four of the roots remained sound. The holes ranged from one-half to two and one-half inches from tips of roots. These roots could not have been present for more than 4 days.

(29) Fifty young centipedes placed in box as in Experiment 28, November 21, in which 3 lalas were planted on same date. Examined November 28. Sixteen roots from one-half to two inches in length had appeared. On 13 of them a total of 19 small, circular holes, mostly through cortex, were present. Three roots remained sound.

Since recording Experiment No. 29, a further test, No. 30, has been completed, which is of interest. On December 4, 2 lalas were planted in a box of sterile soil, containing 40 young centipedes. This was examined on December 16. The cane roots produced in this box were thus exposed to centipede attack for about 12 days, which is about a week longer than in any of the previous experiments. A total of 16 roots had appeared, from one-half to four inches in length, bearing a total of 31 holes or lacerations, made by the centipedes. None of the roots were uninjured. Four of the roots had the growing tip completely destroyed. Three other roots bore one hole each near the center, which not only penetrated the cortex, but extended so far into the central cylinder that the root was nearly severed in half. These three roots were badly rotted. The remaining nine roots had from 1 to 5 of the typical, small, circular holes through the cortex.

Checks on the above experiments follow:

(1) All centipedes were picked out of the soils in jars of Experiments Nos. 18, 19, 20, 21 and 22 October 28, without otherwise disturbing or treating the soil. In these jars, sound, sterile soil-grown roots were inserted October 28, there being 4, 4, 4, 3 and 2 roots to the 5 jars respectively. These were removed and carefully examined November 30. All were perfectly sound and bore no holes.

(2) All centipedes were picked out of the soil in Experiment Box No. 28 and 4 clean lalas, or shoots, without roots, planted in the soil, without otherwise treating the soil, November 14. Examined November 22. Thirty-two vigorous young roots from one-half to three inches long were present. All were absolutely sound and bore no holes.

In all of the above experiments, it should be noted that in no case were the roots exposed to centipede attack for much more than 4 days, if that long. No great success was had in working with the young centipedes until the method adopted in Experiments 28 and 29 was used, for in the others the roots soon lost their vigor after being changed from sand to soil or one soil to another. The eye plantings were not entirely satisfactory in securing growing roots, as a part of the fermenting stick was planted with the eye and not enough time elapsed for vigorous eye roots to grow.

As the root holes appearing on the roots in the experiments are identical with those found in the field and as this centipede is exceedingly abundant in cane soils in Hamakua and Kohala, where I have searched for it, I ascribe a great deal of this root marking, in these localities at least, to the centipede. Snails, of minute size, are present in the soils here, but I have difficulty finding many of them, excepting in a few spots, and particularly deep in the soil, where roots are penetrating. I find the centipedes following the roots at all depths, however.

Paradichlorobenzene is highly fatal to the centipedes.

On November 22, 1924, I placed 60 freshly collected centipedes in a wooden box containing 220 cubic inches of slightly moist soil. Into this I mixed three-fourths ounce by volume, of paradichlorobenzene. Two days later, upon examination, all centipedes were dead and only a small amount of the chemical had disintegrated.

On November 25, I placed 60 more freshly collected centipedes, 3 being adults, in the same amount of soil and mixed in one small teaspoonful of paradichlorobenzene. Twenty hours later found them all dead.

On November 26, I cleared away all grass and trash from 10 feet of row of 1-year old Yellow Caledonia cane. This space bore 22 sticks of cane. Over the surface of this space I sprinkled 3 ounces of paradichlorobenzene, the area being 10 feet long by 2½ feet wide, and loosely covered the chemical with one-half inch of soil. Two days later I removed from this soil 62 centipedes at depths ranging from 2 to 9 inches, 41 of which were dead. There were 10 adults, only 1 being alive. As most of the flakes of the chemical were still present, its poisonous fumes would no doubt continue to operate for many days longer and a higher percentage of dead would have been found if I had waited longer. The soil still smelled strongly of the substance.

This material may prove of great value to us, as a soil fumigant, in time, if soil fumigation should prove useful by later experiment. I have no data at hand as to its cost.

The Duty of Labor*

By J. S. B. Pratt, Jr.

A subject that has not been discussed much at our meetings, or at the Planters' meeting, is the "Duty of Labor." By this we mean, how much a man can do on the various tasks in a day. And connected with this is, how can we get that man to do more?

The duty of labor is a matter of conditions. That is the reason it is so difficult to present a paper on this topic. One immediately says, "Our conditions vary so much even on our own plantation." We hear the statement, "Ten years ago our laborers did much more work than they do now." How do we know? Do we have a standard of comparison, or are we thinking of the outstanding individuals?

Feeling that it was a subject we plantation men are all interested in, and want to discuss, the writer sent out a large number of questionnaires. Replies were received from J. T. Fantom, of Puunene; A. T. Spalding, of Honomu, and W. L. S. Williams, of Waiakea, and their answers helped materially in this paper. The rest of the material presented comes from the writer's own experience on different plantations, and from copious notes taken in travels to all the plantations.

Plantation Labor Requirements

An easy ratio to remember for labor required for a plantation, is one man to 5 acres for the irrigated places, and one man to 7 acres for unirrigated. This includes all labor: mill, field, sundry, etc., or is the total labor to the total acres in cane.

Approximately 65 to 70 per cent of the total labor is actually engaged in raising and harvesting the cane. The 35 to 30 per cent balance is for the mill, construction, overhead and sundry jobs. It can be estimated that most plantations use 10 per cent of the total labor in the mill, with the other 20 to 25 per cent overhead, repairs, sundry and construction jobs. The percentage for the mill depends on the size of the plantation.

During the harvesting season, 20 to 25 per cent of the total labor is required for the harvesting fields, divided roughly as follows: 15 per cent for hauling and track, 40 per cent for loading, 45 per cent for cutting.

The labor requirement per ton of sugar is influenced by the yield per acre, and the quality of the juices, but the above mentioned ratios are good approximations per acre.

Man vs. Woman Labor

Although a woman's rate of pay is usually 75 per cent that of a man's, there are certain operations in which she can equal a man day's work. Irrigating, weeding, fertilizing, picking up cane, piling cane, cutting seed, setting seed,

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* **Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.**

covering and planting are all operations in which she may excel, depending largely on the individual and on the luna. But as these operations are generally on a contract basis the pay is based on the work actually done. All lunas cannot handle wahine gangs or school children gangs, and it pays to find good lunas for them. Better work is done by wahine gangs if they are separated from the men.

Child Labor

School children of advanced age often work for short periods of time. The superintendence of school children is mild, and they work at the easier jobs, as in setting seed in planting, in which they excel. As with the school gardens, this light plantation work has great educational value in teaching proper agricultural practices, and in stimulating an agricultural interest.

Handling Labor

In Hawaii, we find three main schemes for handling labor:

(1) Day work;
(2) Piecework or ukupau;
(3) Contract work.

Add to this, a possible fourth, the combination of ukupau and contract work.

In (1), we have the most expensive and slowest work. Certain jobs requiring careful work as in weeding in young plant cane may be best done by day work. Here the overseer must see that the man gets a day's work done.

In (2), a certain task is given, as for example, to cut ten bags of seed and pack to the cars, or to hoe forty lines of cane. This system works well with the psychology of a large amount of our labor, that is, the thought that when the task is completed, he can go *home*. This method requires closer supervision to see that the task is done well, but at least a day's work is done. Ukupau is a good system where the overseers are on the job, but careless work results unless they are. The tasks should not be set by the sub-lunas, as they often want to go home as badly as the men do.

In (3), contract system, we find a method very common in the Islands. The term "Long Term Contracts" usually refers to the growing of cane, often over a two-year period, under contract. Remuneration is received from tonnage raised. "Short Term Contracts" are petty contracts for short periods of time. By this, a man is paid for a certain task, and the more work accomplished the more money he earns. Here, the overseer does not have to urge the men on, but devotes his time to seeing that careless work is not done. A man is justly paid for what he earns. A contract may be taken by a group of men or by individuals.

The fourth method of a combined ukupau and contract is being used more and more by plantations. By the ukupau method (3), all men in the gang usually get the same task and receive the same money per day. The contract system when individual, gives the man what he earns. Some places combine these methods, i. e., when a man earns by contract a set amount, usually say 10 per cent above his daily base rate, he is allowed to go home (like ukupau), but he may stay to earn more (contract method).

The writer believes this is the best method, where applicable, with our present laborers. The way to get the most work out of a man is to place him on an individual task. The good man gets more money than the poor man. This combined contract and ukupau is ideal in that the home psychology enters, and yet a man may do more than under ukupau. It works nicely in hoeing contracts, and several plantations use it in cutting cane.

It would be a big mistake to cut a rate when it has been set incorrectly and a man is making big money. The rate is based on so much per acre, or per line, etc., and what an individual makes is not the criterion; but what is, is our cost per acre or per ton cane. The more a man earns at that rate, the more work we are having accomplished. The most success in handling contracts is obtained by sticking to a rate while the job lasts, or the conditions remain the same, and if one has made a mistake in setting the rate, to learn not to do it next time.

It is equally as bad to have a contract and do as many plantations do, figure out the contract after the month or job is over at a certain rate. This is no contract at all, and the making up of a contract up to a certain amount is also bad. Pay them what they earn.

On Increasing Our Duty of Labor

(1) Inculcate the idea of money earning in the men.

(2) Better overseers, and closer instruction of them.

(3) Have the overseers train the individuals in the details, as in the correct way to use the hoe, to cover seed, or to cut cane.

(4) Short cuts. The interesting part to our plantation work is that there is always something new coming up. Simply because a job has been done a certain way for the last fifty years is no reason that it should be done that way another fifty years. We may have a new cane requirement, conditions may have changed, or we may have been making mistakes for fifty years. So, study the details, and look for short cuts.

(5) See what your neighbor is doing. Travel around and get out of the rut. He may be doing your job in a quicker way than you are. "Talk shop" with him.

(6) There are many unnecessary jobs or motions; cut them out.

(7) The only way to increase the duty of labor is to first find out what your labor is doing. How much are my men irrigating per day, how many tons cane can they cut, etc.? Finding out this, one automatically tries to do better, but unless one knows what his men can do, he may never hope to get more work out of them.

(8) Do the job at the right time. Try to get the weeds, for instance, when they are light rather than when they are heavy, for heavy weeding takes the pep out of the men. It is better to do two light cultivations than one heavy cultivation.

Conditions vary, and averages do not show much, but we all like to hear how the other fellow is doing it. Yet, by experience we all come to have an idea of what a day's work is, else we could not set any contracts. We know a man cannot cut twenty tons of cane a day, but we have a range of say four to eight tons in our mind as a day's work. The new man coming in to the industry wants to

know, so it is hoped that the accompanying tables will be taken as a "starter" on this important subject, and that others may add to this each year.

The items are lettered and discussed under the headings after the table.

TABLE SHOWING APPROXIMATE RANGES FOR A DAY'S WORK (10 HOURS)

OPERATION—

A. Clearing: Rock (heavy), 60 men per acre.
Lantana, 4 to 10 men per acre.
Koa, 5 to 20 men per acre.
Guava, 10 to 20 men per acre.

B. Steam Plowing:

Plowing: Acres plowed per day, 4 to 8 acres.
Men per acre, 1 to 4 men.

Harrowing: Acres per day, 10 to 35 acres.
Men per acre, 1/2 to 1/7.

C. Caterpillar Plowing and Harrowing:

3 disc gang plow: Acres plowed per day, 4 to 7.
Men per acre, 3/4 to 3/7.

Harrowing: Acres harrowed, 15 ±.
Men per acre, 1/5.

Plowing*: *Engine gang, 4–14", 2 men, 14–18 H. P., 8 acres per day (10 hrs.).
*Engine gang, 4–14", 2 men, 20–25 H. P., 12 acres per day (10 hrs.).
*Engine gang, 4–14", 2 men, 25–30 H. P., 16 acres per day (10 hrs.).

D. Animal Plowing:

*Walking plow 12", 1 man, 2 horses, 1.6 acres per day (10 hrs.)
*Walking plow 14", 1 man, 3 horses, 2.3 acres per day (10 hrs.).
*Sulky Plow 14", 1 man, 3–4 horses, 2.5 acres per day (10 hrs.).
*Gang 2–14" bottoms, 1 man, 4–6 horses, 5.2 acres per day (10 hrs.).
*Gang 2–12" bottoms, 1 man, 3–6 horses, 4 acres per day (10 hrs.).
*Gang 3–12" bottoms, 1 man, 5–8 horses, 6.6 acres per day (10 hrs.).
*Gang 2–8" bottoms, 1 man, 2–3 horses, 2.8 acres per day (10 hrs.)
*Gang 3–8" bottoms, 1 man, 3–4 horses, 4.2 acres per day (10 hrs.).
*Deep tillage 2–20" disks, 1 man, 6 horses, 2.5 acres per day (10 hrs).

E. Animal Harrowing*:

*Disk harrow (not lapped) 4', 1 man, 4 horses, 5 acres in 10 hrs.
*Disk harrow (not lapped) 6', 1 man, 6 horses, 9 acres in 10 hrs.
*Disk harrow (not lapped) 8', 1 man, 8 horses, 14 acres in 10 hrs.
*Spike harrow (not lapped) 8', 1 man, 2–3 horses, 10 acres in 10 hrs.
*Spike harrow (not lapped) 16', 1 man, 4 horses, 30 acres in 10 hrs.
*Spike harrow (not lapped) 24', 1 man, 6 horses, 40 acres in 10 hrs.
*Spike harrow (not lapped) 32', 1 man, 8 horses, 60 acres in 10 hrs.
*Spring tooth, 6', 1 man, 3 horses, 9 acres in 10 hrs.
*Spring tooth, 8', 1 man, 4 horses, 12 acres in 10 hrs.

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* Adams' Farm Management, p. 547.

F. Furrowing:

Caterpillar: 1 Mouldboard, 4 acres per day; 1/2 man per acre.
2 Mouldboard, 8 acres per day; 3/8 man per acre.
3 Mouldboard, 12 acres per day; 1/3 man per acre.
Animals: 1 Mouldboard, 4 animals, 4 acres per day; 1/2 man per acre.

G. Preparing and Ditching:

(a) Preparing (hukilepo): Men per acre, 2 to 4.
Lines of 30′ per man, 150 to 75.
Canoe plow, 2 horses, 4 acres per day, 1½ men per acre.
(b) Ditching usually 2′ x 2′, 1 man does 75′ per day.

H. Cutting Seed:

Top-seed ahead of cutters—bags per man, 15 to 20.
pounds seed per man, 975 to 1,300.
cutters leaving seed—bags per man, 20 to 30.
Body seed: Bags per man, 30 to 40.
Pounds per man, 1 to 1¼ tons.

I. Hauling Seed:

Pack-saddle: Bags per man, 150 to 350.
1 pack-saddle man to 10 planting.

J. Planting:

Preparing, planting, covering: total men per acre, 4 to 5.
Preparing, 1 to 3.
Dropping and setting seed, 1.
Covering, 1 to 2.
Bags per acre (65 lbs. each), 60 to 80.
Bags per man (setting seed and covering), 25 to 35.

K. Replanting: Variable (1 to 3).

L. Irrigation:

(a) First water 30′ lines—
Lines per day per man, 80 to 200.
Men per acre, 4 to 1½.
(b) Small cane—men per acre, 1 to 2.
With weeding, 2.
Without weeding, 1.
(c) Big cane—men per acre, 3/4 to 1.
Orchard system—first water, 1/4 to 1/6.
Subsequent, 1/10 to 1/20.

M. Cultivation Contracts:

Plant cane, 5 to 10 acres per man.
Ratoon cane, 7 to 13 acres per man.
Total man-days per acre (hoeing and irrigating, long term contracts)—
Plant, 30 ± days per acre.
Ratoon, 20 ± days per acre.

N. Fertilizing (by hand): 10 to 15 bags per man.
Estimated Sliding Schedule—Spreading only—
3 bags per acre, 9 bags per man, 1 man 3 acres.

4 bags per acre, 10.5 bags per man, 1 man 2.6 acres.
5 bags per acre, 11.5 bags per man, 1 man 2.3 acres.
6 bags per acre, 12.5 bags per man, 1 man 2.0 acres.
7 bags per acre, 13 bags per man, 1 man 1.8 acres.
8 bags per acre, 13.5 bags per man, 1 man 1.7 acres.
10 bags per acre, 14 bags per man, 1 man 1.4 acres.
125 lb. bags.
Bags packed per day—100 per man.

By wagon:
1000 lbs. per acre, 2 horses, 1 man—45—60 bags per man.

* **Manure Spreader** (75 bu.):
1 man, 2 horses; loads in 10 hours—12.

* **Spreading Lime:** drill (10′):
1 man, 2 horses; acres per day—11.

* **Spreading fertilizer:**
1 man, 2 horses; acres per day—13.

O. Hoeing:

Light weeding: Men per acre, 2—4.
Lines (30′) per man, 150—75.
Medium weeding: Men per acre, 4—8.
Lines (30′) per man, 75—40.
Heavy weeding: Men per acre, 8—12.
Lines (30′) per man, 40—25.

P. Cutting Back:

No hoeing (knives):
Men per acre, 2/3 to 1.
Lines (30′) per man, 200—300.
With hoeing (hoes):
Men per acre, 2—4.
Lines per man, 75—150.

Q. Harvesting, Irrigated:

1 good man cuts in 30 tons cane burned about 8 tons.
1 poor man cuts in 30 tons cane burned about 5 tons.
1 good man cuts in 30 tons cane unburned about 4½ tons.
1 poor man cuts in 30 tons cane unburned about 3 tons.
1 good man cuts in 60 tons cane burned about 9 tons.
1 poor man cuts in 60 tons cane burned about 6 tons.
1 good man cuts in 60 tons cane unburned about 5 tons.
1 poor man cuts in 60 tons cane unburned about 3½ tons.
Loading: Burned cane, 10 to 15 tons per man.
Unburned cane, 8 to 10 tons per man.
Portable track: Lay and take up, about 240 ft. per day.
Ratio: Trackmen to cutters, 1 to 5.
Loaders to cutters, 4 to 5.

Harvesting, Unirrigated:

1 good man cuts and packs to flume 3½—4 tons cane.
1 poor man cuts and packs to flume 2½—3½ tons cane.
1 good man cuts in burned cane 5—7 tons.
1 good man cuts in unburned cane 3—5 tons.

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* Adams' Farm Management.

1 poor man cuts about 3½ tons.
Loading to flume—tons per man, 6—8 tons.
Fluming per man 20—30 tons.
Pickups—Ratio: pickups to cutters 1 to 50.

R. Palipali: Medium Trash:

Men per acre, 2—3.
Lines (30′) per man, 100.
Lines (210′) per man, 19—20.

S. Stripping: Men per acre, 2—6.

T. Cultivation:*

*24″ space,	1 man,	1 horse,	4	acres	in 10 hours.
*30″ space,	1 man,	1 horse,	5	acres	in 10 hours.
*42″ space,	1 man,	2 horses,	6½	acres	in 10 hours.
*48″ space,	1 man,	2 horses,	7½	acres	in 10 hours.
*66″ space,	1 man,	2 horses,	10	acres	in 10 hours.
*84″ space,	1 man,	2 horses,	12	acres	in 10 hours.

Big Horners going once: acres per man, 2¾.
twice: acres per man, 2.
Planter Jr. once: acres per man, 4.
twice: acres per man, 2.

Hilling Up:

Plows only: men per acre, 3—5.
animals per acre, 2—2½.
Canoe Plows: acres per day, 4.
men per acre, ¼ to ½.

Off-barring:

Men per acre, ½.
Animals per acre, 1.
Tractor, small, acres per day, 12.
Tractor, 3-10″ plows, 4 men, acres per day, 8.

U. Miscellaneous:

Poepoe—Lines per man, 75.
Spraying—Acres per man per day, 1¼.
Seed sprayer—Acres per man per day, 5.
Track: Main line—
Ties dipped per man per day, 200.
Ties dipped per 50 gal. bbl. (4″x6″x5′), 700.
Ties tamped per day per man, 90.
Feet spiked and fish-plated—180 feet for 2 men.
Take up old rail, put in new—3 men per 100 feet.
Track Maintenance: Daily per mile—1 man.
Fences:
Holes dug per man per day, 35—40.
Holes tamped per man per day, 50.
Fence put in, stringers and all, feet per day per man, 50.
Old fence taken up, feet per man, 75—100.
Take up and put in, feet per man, 30.
Posts dipped per man per day, 300.
Posts dipped per 50 gals., 1000.

* Adams' Farm Management.

Forestry:

Dig holes, plant and irrigate: trees per man, 40—50.

Clear brush, dig holes, plant and water: trees per man, 40.

Concrete:

1 man should average 1½ to 1¾ cu. yds. concrete in 8 hrs., including mixing and wheeling not more than 50 ft. (Farmer's Bul. 1279.) 1½—1¾ yds. per man

Earthwork:*

* Loosening—Pick: ordinary loam, 3—5 cu. yds. per hr.
* hardpan, .5—1 cu. yds. per hr.
* Plow: ordinary loam, 40—50 cu. yds. per hr.
* (4 men) clay, 25—30 cu. yds. per hr.
* hardpan, 15—20 cu. yds. per hr.

Shoveling:*

* Pick and shovel—yds. per man, 7 cu. yds. per day.
* Loosened earth to wagon, 1.2 to 1.5 yds. per hr.
* Loosened earth from platform, 2—2.5 yds. per hr.
* Spade and load: brick clay, 20—40 cu. yds. per day.
* Pick and load: loam, 1 cu. yd. per hr.
* stiff clay, ¾ cu. yd. per hr.
* hard-pan, ⅓—½ cu. yds. per hr.

Scrapers:*

*Fresno scraper, depending on length of haul and soil: yards per day, 60—120 cu. yds. per day.

Wheelbarrows:*

* Pick and load into wheelbarrows, loam per man, 1 cu. yd. per hr.

Digging cesspool—8'x8'x10': Sq. ft. per day, 75.

Digging ditch—2'x2': Feet per man per day, 75.

Tunnels: **Example**—3'x5' soft earth, 32 ft. long: Feet per man per day, 4½.

Sand: Waianae sand—Lbs. per cu. yd., 2400—2600.

Cu. ft. per ton, 31.

Yds. sand load in car per day, 15.

Yds. sand unload from car per day, 20.

Rock: Loading crushed rock in bags per man, 50.

Breaking large rock for crusher: Yds. per man, 3½.

Stone wall: 3'x3½'—Rock nearby: Feet per man per day, 13—20.

Firewood: Cords per man per day, 1—2.

Cane-tops to stable: Ratio, men to animals, 1 to 50 or 100.

Discussion

A. *Clearing:* This operation usually refers to the taking in of new land. Removing rock, cutting brush, or otherwise getting the land ready for plowing is termed "clearing." One plantation has done extensive rock clearing, piling the rock in large piles in the field. The rocks are plentiful and 12 men can clear only 5 acres per month, or 65 men per acre with the aid of two steam plows dragging sleds or chains. Some plantations have brush or koa, taking as many as 20 men per acre grubbing. Lantana may take 5 to 20 men per acre grubbing, depending on rocks present.

* American Civil Engineers Hand-Book.

B. *Steam Plowing:* The size of the field, topography, depth plowed, condition of soil, amount of trash or rocks cause the men per acre to vary.

For an entire season, one plantation averaged 5 men per acre, to include two plowings and two harrowings. One set of steam plows plows between 4 to 8 acres per day with a total of 2 drivers, 1 on water and fuel, 4 on plow, or a total of 7 men. In very rocky land, one set may not make more than 2 acres per day. With no rocks, one set averaged 9 acres per day over a 300-acre field on first plowing. With a flexible tooth harrow, 12 feet wide, 18 acres were steam plow-harrowed in this field. On level land in large fields, with the disc harrow, 35 to 50 acres per day may be done. Approximately half of the total plowing cost is for labor.

A saving in man and animal labor has been made by several plantations recently, by substituting a small tractor to pull the water and fuel carts, one tractor pulling two water wagons with fuel.

C. *Caterpillar Plowing and Harrowing:* With a 60 H. P. tractor, and 3 gang disc plow, 6 acres per day is good plowing, or one-half man per acre. Plowing on a 24-hour shift, the pineapple people figure 15 acres for the 24 hours, or 7 acres per day. Good land is plowed at night, the poorer stretches in the day. Between 4 and 7 acres is good caterpillar plowing for a 3-disc gang plow, using 3 men. "An average duty of machinery is 1.4 acres as a day's work for each foot wide that a machine covers." (Warren's Farm Management.) A small type tractor can harrow 5 to 8 acres per day. The amount of harrowing done depends on the speed and width, but a good figure is "1.5 acres per foot of width, with 2 acres per foot width for plows." (Adams' Farm Management.)

D. Animal plowing is done in only the small, unhandy places where the tractors cannot work. The amount of work per man and animal would vary for that reason. The table gives some mainland standards.

E. The table gives animal harrowing figures on the mainland.

F. Perhaps the factor most affecting a good day's work in furrowing is topography. If there are many turns, the area furrowed is cut down considerably. The area furrowed also depends on the width of row; perhaps 5 feet apart is more commonly used. Furrowing is often done on Hawaii by 10" plows run both ways in the line.

G. *Preparing, Called "Hukilepo":* This operation is done very thoroughly on the irrigated plantation to give a good furrow for water. The amount of preparing depends on the soil texture. If grassy and lumpy, a man may only make 100 lines of 30-foot length per day. Then again he may make 150 and up to 200. A big labor saver has come in the use of the canoe plow (modified celery hiller). This makes the furrow after mouldboarding in excellent condition to plant, in fact, often no further preparing is needed except on the field edges. One big horse can be used, and it is best to change off at noon. More often two animals pull one canoe plow. One man can drive it, but if there are many curves and turns, two men make a better job. They may do 4 acres a day. "Hukilepo" in ratoons comes under the term hilling-up. Seventy-five to 150 lines of 30-foot will be a day's work on this operation.

Ditching, for irrigated plantations, is most often done by pick and shovel. Seventy-five feet for a 2′x2′ ditch is good, but this cannot be done if there are any rocks.

H. *Cutting Seed:* If any plantation job requires knack, it is seed cutting. An expert cutter can cut three times the amount a poor cutter might cut. It pays to weed out the poor seed cutters and instead of having a large gang giving harder supervision, to have a small gang of reliable seed cutters. The amount cut per man varies a great deal with the stand of the cane. A man cuts much more seed in heavy cane. He loses less time. Some places pay so much per bag loaded to the cars, others leave the seed in the field and have packmen pack the seed out. The writer believes it best to have the men cut the seed, get it inspected before sewing at the outside of the field, then at the end of the day, have each man place his seed on the car or truck. Some new seed cutters may only make 8 to 10 bags per man, while expert cutters can make as high as 35 to 40 bags and pack same out. Some places require the men to sew their own bags, others have men to sew and throw out poor seed, and to make full bags. 15 to 20 bags is perhaps a standard figure per man for top seed.

I. *Hauling Seed in the Seed Cutting Field and Planting Field:* Excellent packsaddle men are hard to get. An ordinary man may pack only 150 bags per day, whereas a good packman can pack 350 bags per day. The number of pack animals and distance have a bearing on amount packed.

J. *Planting:* Preparing, dropping seed, setting and covering will take about 5 men per acre. On irrigated places add 3 men more for first water. Assume we have a 20 men gang. We may use 2 men on packsaddle, 5 men hukilepo (preparing), 2 men dropping seed, 1 opening bags, 4 on setting seed, 6 on covering, and we may plant 350 bags, or 5 to 6 acres, depending on the seed spacing. First water on irrigated plantation will take another 2 to 3 men. Between 25 and 35 bags per man is a day's work for setting seed and covering. One unirrigated plantation man figures with a gang of 44 men and boys, 12 will be used for preparing, 1 on packsaddle, 8 on dropping seed and opening bags (boys), and 24 setting and covering; 360-400 bags will be planted, or 9 to 10 bags per man. Here, however, setting seed is done by hand, each seed-piece being placed by hand at an angle depending on the wetness of the soil.

The number of bags per acre and planting rate depends a great deal on the width of rows and spacing of seed, for the number of bags of seed may run from 60 to 100 bags per acre. Figures taken from planting on a plantation over a large field, somewhat hilly, indicate a day's work. One man cut 15 bags seed and packed his own seed to car. One man prepared 200 lines of 30-foot length. One man planted 36 bags, setting and covering, or 125 lines. One man irrigated 90 lines on pali, and 150 on level, putting in trash panis. With a gang of 40 men, 8 were preparing, 13 planting, 19 irrigating. It took 32 men to cut seed for this gang of 40 men.

For sewing bags, 1 pound of twine will tie 120 bags. Figure on one-eighth pound per man.

K. *Replanting:* This varies so much that it is difficult to give even a general idea of a day's work. It depends on the soil in which the seed is being planted,

in the number of openings to be dug and in the amount of replant. No figures are available, but the best way to determine the amount is to estimate what per cent of the lines is the average to need replanting. For instance, if one-fifth of the lines need replanting, we will require about 15 bags per acre for the replanting. Perhaps this will take 2 men a day to complete. Where the replanting is light, the quickest way to do is have each man have a half bag made into a knapsack carrying seed. He makes his own hole, drops his seed and covers it. This keeps the seed and hole from drying out. Where replanting is heavy, do the operations separately.

Irrigation

L. (a) *First Water:* This depends on the system, topography, texture of soil, flow of water, and inches per irrigation. On the first three waters, the water should be shut as it reaches the end of the line, as there are no roots developed. One man can put in panis and irrigate about 85 lines on palis, and up to 200 lines on the level, but a good average figure for first water is 125 lines, with 300 lines per acre.

(b) *Small Cane:* Often if there is no weeding, a man handles two or three watercourses. Then one and a half to two acres may be irrigated per day. Quoting from W. P. Alexander's Bulletin on Irrigation of Cane: "The average was 1.13 acres per man for the standard system before winter, and .76 acre per man in big cane time."

Perhaps a good figure to have in mind is 2 men per acre in the small cane where weeding is done, and 1 man an acre in the large cane. If weeding is taking more than 2 men per acre it is a waste of water, and should be done as a separate operation.

(c) *Big Cane:* The flow of water determines the amount irrigated in big cane. The great difficulty is in preventing an over-irrigation, so the use of the watch is recommended, and a time per line set. Two minutes per line of 30 feet gives about an acre a day with the flow ordinarily used by one man. A man should make an acre a day in big cane. If not, the chances are that the line is being filled too full, resulting in over-irrigation. The writer has found that it is largely a question of overseers as to the speed attained. He has tried switching lunas, and finds that the same men can irrigate fully 50 per cent more with one luna than with another.

The amount per day will be larger when irrigating up a watercourse than when irrigating down, as the panis are already made and the man is less apt to fill the line too full.

Allen reports that "one man with a flow of 77,000 gallons can irrigate 1.375 acres per day by the double line method, and 1.385 acres per day by the single line method."

M. *Cultivation Contracts:* These are termed "Long Term Contracts" and usually run 460 days or 18 months. The contractors do all the cultivation (hoeing and irrigating). The number of acres handled per man varies according to the amount of weeding to be done, and to the number of irrigations. It varies from 5 to 10 acres in plant, to 7 to 13 in the ratoon. An average of all cultiva-

tion contracts for 5 plantations for two years is 8.2 acres per man for both plant and ratoon. The plant fields are more apt to be taken up on contract unless heavy weeding is expected. "Kokua," or extra help, is charged to the contract. One irrigated plantation figures 7½ acres on plant, 8½ on ratoon per man. Another figures 5 on plant and ratoon, 10 and 13 respectively for another place. One irrigated plantation figures 8 to 10 acres on plant per man, 9 to 12 on ratoon.

Days per Acre: Dividing the total number of man-days spent on the contract by the number of acres gives an interesting figure, the days per acre. Taking one plantation, plant cane required 30 days per acre, ratoon 20 days per acre. This included hoeing and irrigating operations only. Hilling-up and fertilizing are usually not charged to the contract. The "days per acre" depends on length of time of contract, weeds and number of irrigations, and speed of the men.

N. *Fertilizing:* Twelve to 15 bags of fertilizer (125 lbs. each) is a good day's work for a man spreading by hand at a 4- or 5-bag per acre rate. New men might spread only 9 or 10 bags. Men who have spread for a long time might make 20 bags per day.

The writer presents a sliding schedule in the table that he has worked out, showing how the rate per acre determines the men per acre. This would vary with the man. Most plantations pay a flat rate per bag regardless of the rate, but a man covers more area with the lighter application, so if a contract is made by acre, a sliding scale should be worked out.

O. *Hoeing by Acre:* Where the grass is very uneven, a contract by acre is the type to give; also when the cane is large, or when one hesitates about trusting a certain luna to count lines. Acre hoeing will take from 2 to 12 men per acre. We very seldom hoe in a field with grass that would take less than two men per acre. The amount of weeds is determined to a great extent by the moisture. Many believe it is as important to get the weeds out of the cane as it is to put water on, for weeds soon dry a field out in dry weather.

By Line: Hoeing by line, either ukupau or contract, is recommended wherever possible, to speed up the labor and to give a good man a chance to make more money. Twenty-five to 150 lines per day, depending on the grass, constitutes a day's work.

P. *Cutting Back:* This operation is done with knives or hoes. Often a hoeing is given at the same time. More often, the trash is allowed to dry and is burned in a couple of days. A man may cut back and hoe only 85 lines, or he may cut back with a knife 300 lines.

Q. *Harvesting:* In Hawaii, most of the plantations burn the trash before harvesting, wherever possible. Where gangs are cutting every day in burned cane, and rains make it so that they cannot burn, one will notice that they may cut fully 50 per cent less cane. It disgusts them, and they do not try. Were they used to it, as on Hawaii where it rains so much and prevents burning, it may only take 25 per cent more men to cut unburned than burned. Where a man cuts 5 tons burned, it can safely be figured that he will cut only 3 tons unburned. A man can cut more cane in hilled-up cane than not hilled, especially if there is trash.

On one irrigated plantation, harvesting gangs for a season averaged about as follows: 450-525 tons cane per day; 55 men cutting; 10 men average on fire-breaks; 45 men loading; 6 on pickups (2 per cent of tonnage was pickups); 13 men portable track; 200 rails laid per day; 15-foot length of rail; 3 rail teams with 2 mules each; 5 drivers hauling cane; 20 animals; 10 brakemen. Certain fields require less hauling, using fewer teams and men. Heavy cane would require fewer men per ton cane for hauling, etc.

On the unirrigated plantations, the same gangs usually cut and then pack to the flumes. The amount of cane flumed will vary as to the grade of the flumes and the water available.

R. *Palipali:* This operation is the piling of the trash in the row, requiring 2 to 3 men per acre. Most plantations burn the trash. The most effective and quickest work can be done in the early morning when the trash is wet.

S. *Stripping:* Most of the unirrigated places give one stripping, taking anywhere from 2 to 6 men per acre.

T. *Cultivation:* With cultivation work, it is very hard to work up a standard. Condition of soil moisture, weeds, rocks and topography are influencing factors. Often cultivators have to go three or four times, so that man-days per acre is variable.

Hilling-Up: After the plows have done the hilling, a certain amount of light hoeing and "hukilepo" or pulling up the soil is necessary. Eighty to 140 lines can be done, 30 feet in length. A line ukupau can be given, but it is fairer to give an ukupau for so many men to a ditch, easily figured when the area is known.

U. *Miscellaneous:* These miscellaneous duty of labor notes are taken largely from the writer's various notebooks from plantation trips, and are merely indications of a day's work.

Poepoe: This term is used on a few plantations to apply to a hilling-up of the cane. It is an Hawaiian term meaning to "round" out, or "circular." It is usually done by pick or hoe. Seventy-five lines is a good day's work.

Cane Tops for Stables: On the unirrigated places, with Yellow Caledonia cane, it is very easy to get good cane tops, and one man may supply enough for 100 animals. On an irrigated place, however, with other varieties, one man often can only cut enough for 50 animals. As in seed cutting, there is a knack in this job, and one man having it could not be replaced with three men.

Most of the other topics under "Miscellaneous" are self-explanatory, and are what have been done under certain conditions.

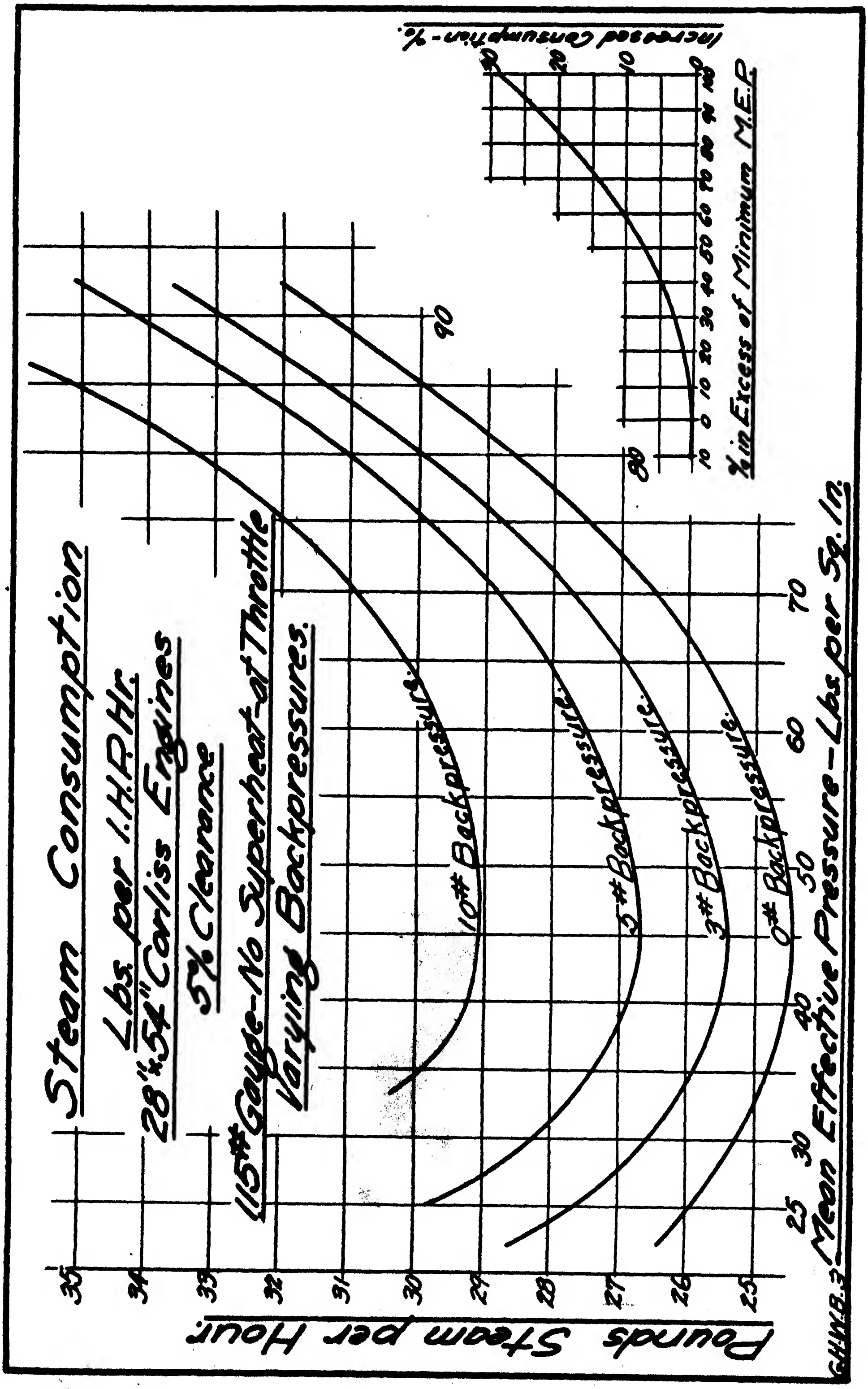
Fuel Economy in the Cane Sugar Factory*

By G. H. W. Barnhart

The subjects of Fuel Economy, Fireroom Efficiency, and Heat Conservation have been well covered in previous papers before this and other Associations, and the writer feels that further discussion of these subjects would be a needless repetition. However, there are some points which came up at the meeting last year, also some queries this year, which have prompted the presentation of the following relative to economical size of mill engines, choice of mill electrical power plant equipment, quantity of boiler heating surface for an economical utilization of the bagasse produced, economizers, presence of carbon monoxide in flue gases, insulation of hot piping in the factory, sizes of steam lines, "extra steam" and filter pressing, which may be of interest.

The general rule for power required in an engine driving a two-roll crusher is fifteen indicated horsepower per ton of fiber ground per hour; thirty per ton fiber ground in a three-roller crusher; and thirty per ton fiber hour for each three-roller mill in a train. This includes power necessary in operating juice strainers and cush-cush elevators, bagasse elevators and other equipment incident to a mill. It is further based on an hydraulic pressure of 75 to 80 tons per lineal foot of top roller. The grouping of crusher and mills with reference to engine drive varies with the installation and designer. The arrangement being known, the power required in the respective engines is readily computed. The choice of speed for crusher or mill engines depends on two considerations. A slow speed involving a minimum of reduction gearing necessitates a very large engine. A high speed with a large gear ratio is not desired, mainly because of the fact that breakages are likely to occur and it is necessary to bring the engines to a stop in as short a time as possible. Furthermore, there is a practicable limit to piston speed. In crusher engines a speed of seventy-five is the maximum desirable, while for mill engines sixty to sixty-five has been found to be the practicable limit. The maximum pressure a boiler can carry determines to a great extent the pressure at which the mill engines will operate. A careful study of Corliss engine diagrams and steam consumption data indicates a minimum steam consumption where the mean effective pressure is about forty per cent of throttle pressure. Reference to the accompanying diagram will indicate to what extent the steam consumption increases or decreases as the mean effective pressure varies from this figure. For a factory grinding fifty tons of cane per hour with a throttle pressure of one hundred and fifteen and a back pressure of five pounds the difference in consumption could readily be fourteen hundred pounds per hour equivalent to two per cent of the bagasse. In an extreme case where the pressure is double the optimum, as where an engine operates just short of the point where it would take steam "full stroke," the extra consumption would be equivalent to nine per cent of the bagasse.

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

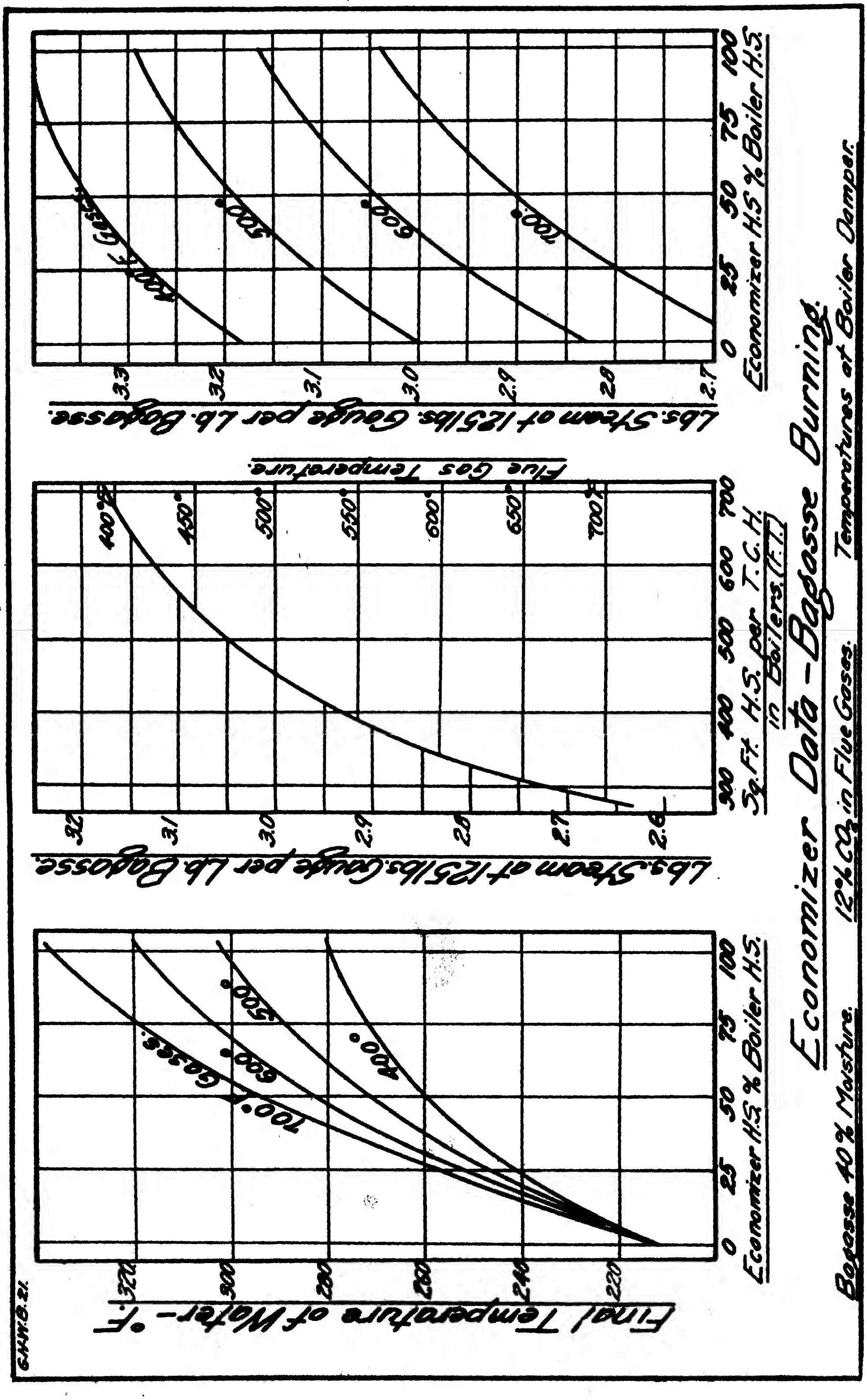

Steam Consumption
Lbs. per I.H.P.Hr.
28"×54" Corliss Engines
5% Clearance
115# Gauge—No Superheat at Throttle
Varying Backpressures.
10# Backpressure.
5# Backpressure.
3# Backpressure.
0# Backpressure.
Mean Effective Pressure—Lbs per Sq. In.
25
30
40
50
60
70
80
90
Pounds Steam per Hour
25
26
27
28
29
30
31
32
33
34
35
% in Excess of Minimum M.E.P.
Increased Consumption - %.
G.H.W.B.3

The ideal arrangement for a mill power plant where much outside power is supplied is a non-condensing turbo-generator running in parallel with a condensing unit, the former to be controlled by a back pressure regulator which controls the load on it so that the pressure in the exhaust lines will be maintained at a constant predetermined point. By this arrangement there will be no serious perturbations in the back-pressure system, the quantity of exhaust steam being always equal to the demand by evaporator, pans, and heaters, no live steam being used in these apparatus, the condensing load being maintained at a minimum. The size of non-condensing unit depends entirely on the extent to which the principle of "extra steam" is applied in the factory. The size of condensing unit will depend on this, and in addition the outside load to be carried. A fair estimate of the requirements can be made in each case, but it must be remembered that the demand for exhaust steam varies considerably according to the fluctuations in the boiling house and each unit must be designed for this variation. However, the extreme peak load in the case of the non-condensing unit occurs but a very small part of the time and can possibly be neglected, as electrical equipment of this type is designed to carry definite overloads for short intervals without harm. The next consideration is the steam rate of the unit. Whereas in central power stations most units are purchased on a basis of full load efficiency and operation is so controlled that only the most efficient machines are delivering power, in the case of a cane sugar factory each of the machines mentioned should be purchased on a basis of average efficiency over the ranges indicated. It will be appreciated at this point that for a given exhaust steam demand, for every kilowatt additional that the non-condensing unit can carry, due to a lower steam rate, the load on the condensing unit is reduced accordingly and a corresponding saving made in bagasse or in the extra fuel bill.

Standard practice indicates a boiler heating surface of 450 square feet in fire tube boilers for each ton of cane ground per hour. This corresponds to 375 square feet in water tube boilers. Both take into consideration the heating surface which may be out of commission for cleaning, etc. Assuming that a boiler operates at rating with flue gases at 500° F., then with other conditions favorable the increase in flue gas temperature will increase the mean temperature difference and the rating in proportion. The ratings and other data will then be:

Temperature Flue Gases	Square Feet Heating Surface Fire Tube	Water Tube	Per Cent of Heating Surface	Boiler Rating Per Cent	Pounds Steam From 212° F. to Steam at 125 Lbs. Gauge
700° F.	283	236	62.9	135.0	2.66
650	312	260	69.2	127.2	2.74
600	353	294	78.5	119.0	2.83
550	395	329	87.8	109.6	2.91
500	450	375	100.0	100.0	3.00
450	530	442	117.9	87.2	3.09
400	676	563	150.1	71.8	3.18

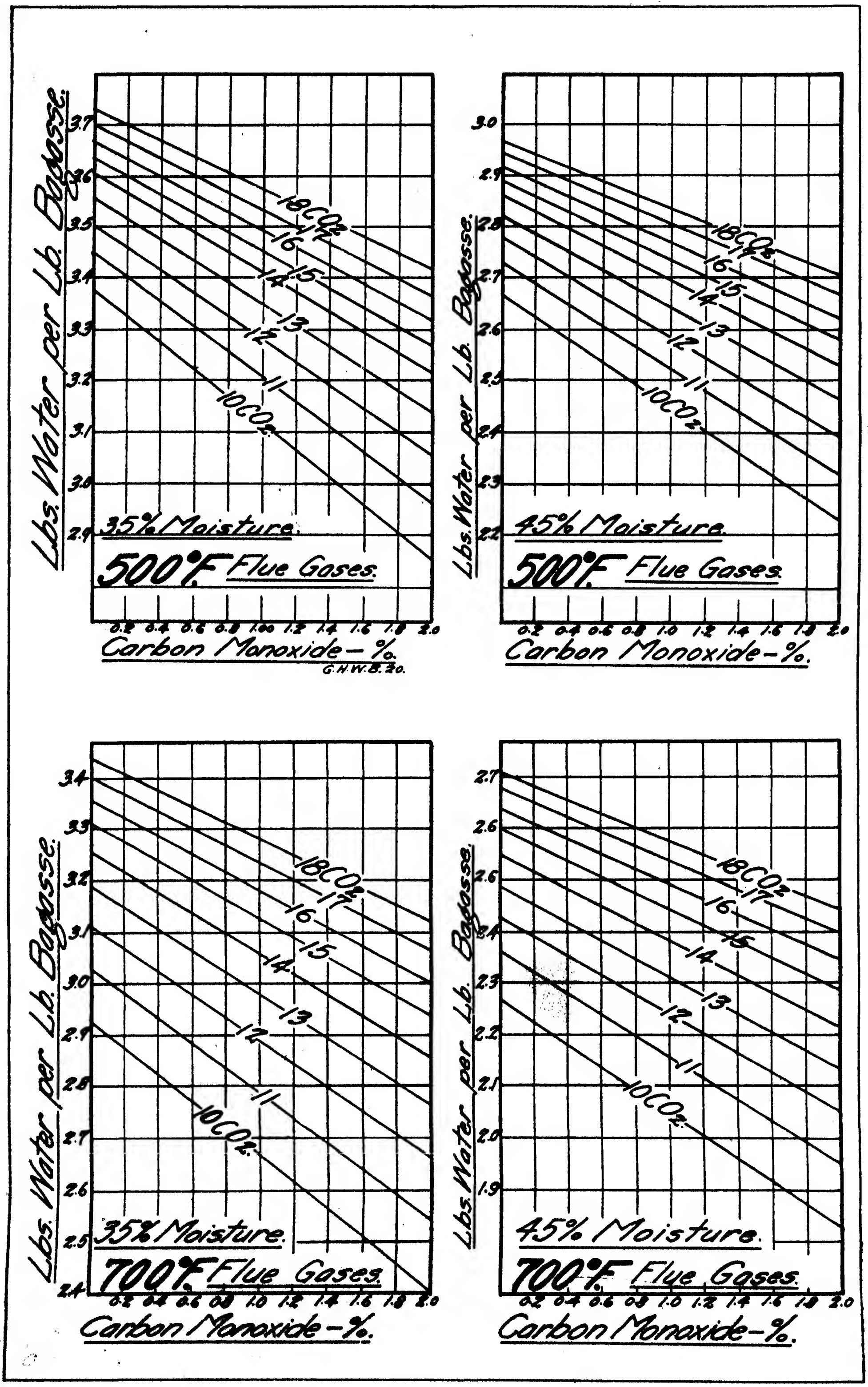
Evidently an increase in rating by raising the flue gas temperature is at a sacrifice in efficiency unless the heat lost can be regained by means of economizers. The accompanying diagram indicates the rise in temperature in boiler feed water from an initial temperature of 212° F. with economizer surfaces installed


Economizer Data - Bagasse Burning
Bagasse 40% Moisture.
12% CO_2 in Flue Gases.
Temperatures at Boiler Damper.
Lbs. Steam at 125 lbs. Gauge per Lb. Bagasse.
Economizer H.S. % Boiler H.S.
Flue Gas Temperature.
Sq. Ft. H.S. per T.C.H. in Boilers (F.T.)
Final Temperature of Water - °F.
G.H.W.B.21.

between the boilers and stack. The central diagram indicates evaporation per pound of bagasse for corresponding flue gas temperatures and heating surfaces, while the diagram on the right gives the evaporation per pound of bagasse with varying combinations of boiler and economizer surface. To obtain, for example, three pounds of steam from each pound of bagasse three combinations are possible, viz., 450 square feet of heating surface in fire tube (375 in water tube) boilers per ton of cane ground per hour; 353 square feet of fire tube surface and 131 square feet (37 per cent) of economizer surface; or 283 square feet of fire tube surface and 232 square feet (82 per cent) of economizer surface. Recent prices covering boiler and economizer installations indicate a price of $3.50 per square foot for economizer surface installed and $3.25 per square foot for boiler surface installed. A comparison of these and other combinations indicates that for equal costs an all-boiler installation will invariably show a better economy than a combination of boiler and economizer. This is of particular interest since operation of an economizer under bagasse burning conditions entails difficulties due to the high moisture content of the heated vapors and a continually lowering heat transmission rate due to the accumulation of particles of bagasse carbon in spite of mechanical scrapers. These particles of bagasse carbon have been described as excellent material for insulating purposes and their accumulation on the tubes of the economizer undoubtedly reduces its efficiency considerably.

In general, bagasse may be said to be burned with a high degree of efficiency if the percentage of CO_2 is from 12 to 14 and the flue gas temperature from 500° F. to 600° F. The writer has gained the impression that those in charge of boiler room operation are inclined to admit too much excess air to their furnaces in order to prevent the formation of any carbon monoxide. This term has been stressed to the point that it would appear to be the "unpardonable sin" of boiler room operation to have CO detected in one's flue gases. Reference to the accompanying set of diagrams will indicate to what extent CO may be tolerated in flue gases. If 12 per cent CO_2 seems to be the safe upper limit for flue gases without CO, then with gases at 500° F. and moisture per cent bagasse at 35 the evaporation F/A 212° F. is 3.5 pounds per pound of bagasse. Then if the CO does not increase above 0.26, 0.54, 0.73, 0.94, 1.20 or 1.46 per cent respectively as the CO_2 is increased to 13, 14, 15, 16, 17 or 18 per cent, just as good work is being done in evaporation. The four diagrams given will supply all information required covering the usual range of fireroom practice. Some of the advantages resulting from decreasing the excess air are decreased load on the stack, a hotter furnace, a higher boiler rating, and a lower flue gas temperature.

Measurements of piping indicate 287 square feet of radiating surface on an average for each ton of cane ground per hour. Of this 189 square feet, or 66 per cent was due to live and exhaust steam piping. Evaporation from bare pipe would be equivalent to 12.64 per cent of the total bagasse produced, while with 1″ Magnesia covering it would be reduced to 1.61 per cent, and with 1.5″ covering it would be reduced to 1.46 per cent. The writer has in mind several factories where, on account of insufficient, poor, or no insulation on the return piping, the temperature of condensate is or has been as low as 160° F. In one instance where attention has been given to this detail the average temperature of the



Lbs. Water per Lb. Bagasse.
18 CO2
17
16
15
14
13
12
11
10 CO2
35% Moisture.
500°F. Flue Gases.
Carbon Monoxide – %.
G.H.W.B. 20.
Lbs. Water per Lb. Bagasse.
18 CO2
17
16
15
14
13
12
11
10 CO2
45% Moisture.
500°F. Flue Gases.
Carbon Monoxide – %.
Lbs. Water per Lb. Bagasse.
18 CO2
17
16
15
14
13
12
11
10 CO2
35% Moisture.
700°F. Flue Gases.
Carbon Monoxide – %.
Lbs. Water per Lb. Bagasse.
18 CO2
17
16
15
14
13
12
11
10 CO2
45% Moisture.
700°F. Flue Gases.
Carbon Monoxide – %.

return has been increased to 210-212° F. resulting in a saving of slightly over five per cent, each ten degree rise being roughly equivalent to a one per cent saving. A further saving, not so easily measured, can be accomplished by the insulation of all steam cylinders, traps, hot juice and syrup lines, heaters, pans, evaporators, settling tanks, and other hot surfaces. The indirect gain will be a cooler factory and more contented operators. The electrification of cane sugar factory equipment as practiced in Hawaii should reduce the radiation surfaces due to live and exhaust steam piping by fully one-half, while careful consideration of the arrangement and location of the various apparatus should account for a further reduction in the quantity of piping.

The proper size for a steam line is generally a compromise between a small pipe necessitating a high velocity and large pressure drop, and a large line occasioning a less velocity and smaller drop in pressure but accompanied by a high radiation loss. A drop in pressure caused by friction is not a loss of energy because the energy reappears as heat. If the steam entering the line is wet, this heat tends to evaporate the moisture in the steam. If the steam is initially dry, the heat tends to superheat it, or if initially superheated, to add to the superheat. The equipment to which the steam is delivered determines whether this heat gained at the expense of a drop in pressure, is utilized or wasted. In general the boilers, the steam lines, and the steam consumers are dependent, each on the other, and all should be considered in the determination of the size of steam line, and the economical size of line is such that the cost of fuel required to generate steam for the operation of the equipment, plus the fixed charges and maintenance on the line, are a minimum.

The extra use of steam—contracted in general usage to "extra steam"—has been discussed frequently as a means of conservation of fuel both in cane and beet factories. In the former the use of double, triple, quadruple and even quintuple effects marks the first step in this process. The use of pre-evaporators supplying vapors for all heating is the second step and will accomplish a seven per cent saving in steam in a factory now applying the "extra steam" principle only in so far as it uses a quadruple effect. Further applications of this principle, which will not be mentioned here, are in common use in beet factories and may effect up to a 31 per cent saving in steam on quadruple effect evaporation alone. The recently advocated pressure evaporation as described by Mr. Terry probably will not find much, if any, application in cane factories owing to dissimilar conditions. The steam compressor, while of advantage in a factory which lacks sufficient heating surface in evaporator or pans, is not an ideal apparatus since it requires live steam in the ratio of about one to one to "boost" the pressure. Where there are no outside power requirements this apparatus is of advantage, particularly where live steam is ordinarily used to make up a deficiency in exhaust steam. It is probable also that it would be used only in the final stages of boiling when the total live steam consumption would be slight.

Fuel economy may be effected at the heater station by the use of well insulated, baffled, heaters while the use of a comparatively high back pressure in the factory will result in a minimum of heating surface with a corresponding reduction in loss by radiation.

Recent developments indicate that the Hawaiian standard of seventy-two cubic feet of settling capacity per ton of cane ground per hour is insufficient. Juices with less than 0.02 per cent phosphoric acid do not settle well even with an excess of lime or capacity. Those with 0.03 to 0.04 per cent phosphoric when limed to phenol alkalinity will settle and leave a limpid juice with somewhat more than seventy-two cubic feet, while those with more than 0.05 per cent phosphoric acid require well over a hundred and ten cubic feet. This increase in settling capacity naturally increases the radiating surface in tanks. For practical reasons it is advisable to have from six to eight settling tanks at this station. The very slight increase in settling time due to a greater number of smaller tanks is not warranted by the increased expenditure or increased attendance necessary. Furthermore, the smaller number of larger tanks involved a smaller radiating surface which should be insulated to the practicable limit.

Pre-evaporators, vacuum pans, evaporators, and juice heaters, have heating surfaces, and correspondingly large bodies, which vary inversely as certain functions of the steam pressure in the boiling house. As this pressure is increased either the rate of work is increased, or the size of apparatus can be decreased for a given amount of work. At the same time the steam lines supplying these apparatus can be reduced in size. Each of these apparatus and also the steam lines to them should be properly insulated.

A large amount of heat is lost at the filter press station on account of the long cycle involved. An added loss is that due to the prolonged washing which adds to the amount of work at the evaporator station. The Kopke separator is the only means the writer knows of whereby the cycle can be shortened and the quantity of water lessened. This equipment has been given a partial trial during the past season and has demonstrated its possibilities so well that centrifugal separation of settlings will be given a thorough trial on a factory scale during the coming year. A consideration from the standpoint of fuel economy would involve a comparison of power required to drive the centrifugals together with the slight radiation loss, with the extra quantity of wash water to be evaporated together with the large radiation loss and loss by inversion of sucrose in the case of filter presses.

Four factors, probably, have contributed to the gradual increase in heating surface required in pans, evaporators and heaters in the cane sugar factory. These are: (1) An increase in the grinding rate, which is a natural result of an increase in acreage, of intensified agriculture, of the aim of the operating force to take off crops during periods which will net the greatest returns to the plantation, and of car shortage. (2) An increase in power requirements, due to the introduction of the Messchaert groove, which, eliminating practically all feeding difficulties, has enabled "setting-up" rollers and increasing the hydraulic pressures carried. (3) A decrease in the operating pressure possible in some factories, due to the limitations of lap-seam boilers and to age in other boilers; and (4) The introduction of the calandria type of vacuum pan, permitting faster boiling, and the substitution of exhaust steam in the calandria for live steam in the coils, which has lead to increasing the ratio of heating surface to capacity from 1 to 2 to 1.2 to 1 and in some cases 2 to 1. The net result of the first three items

has been an increase in the quantity of exhaust steam produced. Back pressures have increased gradually, and where sufficient evaporator surface has permitted, evaporation of syrup to a higher density has been practiced. Water added per cent cane has gradually increased and the evaporation of this has helped reduce the surplus exhaust. Unable or unwilling to purchase and install boilers for higher operating pressures or to install more economical mill engines, the only remaining expedient of increasing the heating surfaces in pans, evaporators and heaters and of burning extra fuel when and where necessary, has been resorted to.

This procedure, the writer feels, is an incorrect and uneconomical one. The installation of an additional pan, a heater, and sometimes the substitution of a larger evaporator, should not be made as a means of reducing exhaust pressure, as this will not be accomplished, unless at the same time, more liquor from which evaporation can take place, is introduced into process. Provided the heating surfaces permit, an actual saving in fuel will be made if the blow-off is set to operate at a lower pressure and the surplus exhaust wasted. The logical procedure in practically all of these difficulties is to replace prime movers which are uneconomical of steam, with apparatus having lower steam rates, or better still to install the more economical apparatus in the first instance, and a surplus of bagasse, indicating that extra fuel is no longer needed, will be the direct result.

Cultivation and Weed Control*

By W. L. S. Williams

For some years, the opinion has been gaining strength that the main purpose of cultivation is the control of weeds. Aeration and loosening of the soil, and drainage, or the conservation of soil moisture, as reasons for cultivating the land, are coming to be looked upon as secondary in importance, except in the case of plowing and preparing land for planting. This opinion is borne out by the results of cultivation experiments carried on by the Experiment Station, H. S. P. A., a tabulation of which is given in the *Hawaiian Planters' Record* for July, 1924. This series of experiments, covering both irrigated and unirrigated plantations, from Kauai to Hawaii, shows that an average loss of 0.2 ton of sugar per acre was recorded from all plots where plows were used, as compared with plots where weeds were controlled by hoes and light cultivators. Similar results have been obtained by the U. S. Department of Agriculture working with corn, no increase in yield being obtained from deep cultivation, as against the omission of the practice, so long as weeds were kept out of the crop in both cases. Quoting Mr. Verret: "This shows that, for average conditions, deep cultivation with plows in growing cane cannot be expected to raise the yield of sugar in itself. The benefits obtained come through weed control."

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* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

The widely varying conditions on the plantations in these Islands give us all our individual problems in weed control. In the irrigated districts, part of the problem will be in keeping weed seeds out of the irrigation water, while weeds which come up in the cane must be controlled by hoeing, the use of animals in lines laid out for irrigation being practically impossible. With the new system of overhead irrigation now coming into use, cane is planted in straight lines, and animals can be employed. In the drier, unirrigated districts, weed control and the conservation of soil moisture are intimately associated. In the very wet districts, drainage is secondary only to the control of weeds.

With the ordinary operations, burning, palipali-ing, off-barring, hoeing, cultivating, small plowing, hilling, weeding, and stripping, we are all familiar. Paper mulching and arsenic spraying are methods of weed control not in such common use. Combinations of some or all of these operations are used on all plantations, the routine combination for any given place being the outgrowth of experience in meeting the conditions obtaining on that plantation. In general, the combinations of operations used fall into the three classes of: irrigated lands, where weeds are controlled by hand labor; unirrigated dry lands, where weeds in the cane row are controlled by hoeing, the centers between the lines being kept clean by animals with light implements after off-barring; and, unirrigated wet lands, where weeds in the cane row are controlled by hoeing, hand weeding, and sometimes paper mulching; while the weeds between the rows are kept down by animal cultivation with plows alternating with lighter implements, some hand labor hilling-up, and sometimes arsenic spraying.

On irrigated lands, where animals are rarely used for cultivating in the growing cane, the problem of disturbing the cane roots is not encountered. On the unirrigated plantations, however, this is not the case. The use of plows in weed control on unirrigated lands can scarcely be avoided, unless paper mulching and arsenic spraying are resorted to. We find that we must off-bar in order to have loose soil for light implements to work in on the drier lands, while in wet districts we must not only off-bar, but split the centers of the rows and hill-up afterwards to get rid of the heavy growth of weeds between the lines. For unirrigated plantations, it is, then, necessary to get the off-barring done as early as possible, preferably immediately after burning off, before many roots have formed. After early off-barring, particularly in dry weather, damage may be done to the stools by drying out, so it is usually good policy to follow off-barring by light cultivators to push the loosened soil back against the stools. In dry districts, weeds in the kuakua can subsequently be controlled by alternate cultivations with Horner harrows and Planet Jr. cultivators. In wet districts, where plows must be used in conjunction with lighter implements, the earlier the plowing and hilling-up are done, the less damage will be suffered by the cane roots. It has been found unnecessary to wait for the cane to close in before hilling-up where the cane has a vigorous growth.

It is interesting to note how the combinations of operations in use on the dry and wet lands conform to the secondary considerations of conservation of soil moisture and drainage. In the dry lands, the fields are left practically level, thus exposing the least surface to the drying action of sun and wind. In the wet dis-

tricts, the cane is left on the ridges with shallow furrows between, which help to drain off excess water, and allow some of the roots to get air, even in long continued periods of rainfall.

In the foregoing, nothing has been said about replanting. In the end, it is the cane itself which controls the weeds in our fields. All we have to do is to give it a start and get it closed in. This cannot be done unless we have a full stand of cane, which in turn depends on keeping our sled and wagon roads, flume and portable track lines, and all other blanks filled up from crop to crop. In the wet districts, transplanting stools for small blanks, and planting up larger areas with seed is the practice. In dry districts, stool transplanting cannot be practiced successfully, and filling small blanks with seed is unsatisfactory unless done very early.

Before closing this brief paper, mention should be made of three or four practices which will be taken up more fully in the discussion to follow. Splitting lines in place of regular round plowing, as preparation for planting has been used quite extensively for the past few years. Puka planting, in place of planting in lines, is coming up in connection with work in bud selection. Soaking of cane seed in a dilute solution of nitrate of soda has been suggested as a method of speeding up germination, and increasing the growth of young plant cane. Stripping, not with regard to its benefits to the crop on the ground, but as it affects the control of weeds in the following crop, is again a subject for discussion.

Our mills have reached the point where improvements are noted in fractions of one per cent, but records are still being broken in the production of sugar per acre. When yields run from two tons up to the record of eighteen tons of sugar per acre, with the average for the Territory at less than six tons, it is evident that the possibility of increasing our average yield of sugar per acre by fifty per cent is by no means hopeless. It is through intensive cultivation, and the raising of our standards in the field, that the sugar industry in Hawaii must hold its own.

Notes on P_2O_5 and K_2O Determinations in Crusher Juice at Pioneer Mill Company*

By J. H. Pratt

This work was continued during the 1924 crop as part of the regular laboratory routine. To date we have a total of 1,518 P_2O_5 and 1,426 K_2O determinations (not counting special samples) and have taken samples from 136 out of 147 fields. Five of the remaining eleven fields will be harvested in 1925, so that the plantation will be pretty thoroughly covered.

A comparison of the averages for the three crops is shown in Table 1. As a rule the K_2O was lower in 1924 than it was in 1923. No reason for this is

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

known, but it is probably a seasonal variation. The P_2O_5 averages, however, seem to check closely. There is a narrow strip, consisting of Fields E 3, F 4, G 3 and 4, H 4, and I 4, which is much lower in K_2O than the adjoining fields, especially at the makai end. In both years, the fields on the Kaanapali side of this strip were found to be lower in both K_2O and P_2O_5 than were those on the Lahaina side of the strip. This accounts for the averages of "G" and "H" being higher in 1924 and "I" being lower. The P_2O_5 is higher in Fields LD, MD and O in 1924 than it was in 1923 and 1922. This, I think, is due to errors in analysis. During the past year, quite a number of samples from these fields were found to give a "false end point." This was not noticed in 1923, except in the case of Yellow Caledonia cane from Olaa, in which it was very marked.

The plant cane is again lower than the ratoons from the same or adjoining fields and in about the same proportion as in 1923:

P_2O_5,	higher in 28 out of 38 comparisons;	average difference 19.84%
P_2O_5/100 Brix,	higher in 26 out of 38 comparisons;	average difference 17.63%
K_2O,	higher in 24 out of 37 comparisons;	average difference 15.07%
K_2O/100 Brix,	higher in 25 out of 37 comparisons;	average difference 14.73%

The short ratoons are again higher than the long ratoons in P_2O_5, being higher in 70 per cent of the comparisons. The average difference is 9 per cent. They are about the same in K_2O.

As very few of the groups of fields were harvested during every month of the crop, it is rather difficult to compare the effect of the time of cutting on the P_2O_5 and K_2O. After considerable experimenting a fairly simple method was invented, which also has the advantage of making allowance for the number of samples taken during the various months. The K_2O shows a steady decrease from December to the end of the crop for both crops. The only exception to this rule is April, 1924. The P_2O_5 shows an increase to a peak in February and then a gradual falling off to the close of the crop. This is also true for both years, except for March and April, 1924.

The effect of the variety of cane on the P_2O_5 and K_2O in the juice is about the same as reported in 1923. Based on comparisons of fields and not on a few sticks or stools, H 109 seems to take less P_2O_5 and K_2O from the soil than any other variety. In 18 comparisons, Striped Mexican is 2 per cent higher in P_2O_5 and 11 per cent higher in K_2O. Lahaina is 8 per cent higher in P_2O_5, but 3 per cent lower in K_2O in 11 comparisons. D 1135 is even higher, in 10 comparisons, it had 12 per cent more P_2O_5 and 32 per cent more K_2O than H 109. Judging from one comparison and from several analyses of a few sticks, Yellow Caledonia takes more P_2O_5 from the soil than any of these four varieties.

As in 1923, there is no direct relationship between the P_2O_5 or K_2O and either the tons of cane or sugar per acre. The average of the fields yielding a juice low in P_2O_5 or K_2O shows less cane to the acre and a much better quality ratio than in the average of the fields which are higher in these ingredients. The "TC/TS" for the crop are:

	P_2O_5	K_2O
High fields	8.58	8.33
Good fields	8.26	8.05
Intermediate fields	....	7.37
Fair fields	7.50	7.25
Low fields	7.04	7.05

This is interesting, although how much of it may be due to the P_2O_5 and K_2O is rather problematical. The "high" fields, for instance, have practically all the short ratoons, they have more tons of cane to the acre, and they get a much larger proportion of pump water. On the other hand, they were cut near the close of the crop when the juice was better than it had been previously.

The relative amounts of cane with varying amounts of P_2O_5 for the last two crops are shown by the following figures:

P_2O_5 per 100 Brix	Approximate Per cent P_2O_5	Crop of 1923 Tons Cane	Crop of 1923 Per cent	Crop of 1924 Tons Cane	Crop of 1924 Per cent
.000–.050	.00–.01	37,084.802	16.70	65,701.084	25.11
.050–.100	.01–.02	99,107.272	44.64	78,556.247	30.02
.100–.150	.02–.03	39,662.662	17.87	49,808.299	19.03
.150–.200	.03–.04	23,198.764	10.45	23,781.407	9.09
.200–.250	.04–.05	6,577.551	2.96	21,314.663	8.14
.250–.300	.05–.06	16,387.640	7.38	17,391.013	6.65
.300–.350	.06–.07	....	....	5,117.629	1.96
Totals		222,018.691	100.00	261,670.342	100.00
Average P_2O_5 per 100 Brix		.1013		.1144	

The amount of P_2O_5 necessary in mixed juice for a good clarification is from .035 to .04, which is equivalent to from .047 to .053 per cent in crusher juice. It is interesting to note that less than 10 per cent of our cane has this amount.

TABLE 1

Number of Samples and Per cent (per 100 Brix)

Field	P_2O_5 1922 No.	1922 %	1923 No.	1923 %	1924 No.	1924 %	Average No.	Average %	K_2O 1923 No.	1923 %	1924 No.	1924 %	Average No.	Average %
A	6	0.666	4	0.028	36	0.054	46	0.053	4	0.827	36	0.548	40	0.576
B	14	0.095	46	0.063	81	0.067	141	0.068½	50	0.902	80	0.507	130	0.659
C	5	0.130	32	0.113	42	0.117	79	0.116	29	2.055	41	1.622	70	1.801
D	.	....	23	0.214	44	0.218	67	0.217	19	1.679	42	1.574	61	1.607
E	3	0.057	12	0.052½	17	0.062	32	0.058	12	0.798	18	0.650	30	0.709
F	3	0.058	27	0.052	34	0.055	64	0.054	28	0.789	34	0.510	62	0.641
G	2	0.060	16	0.057	30	0.084	48	0.074	17	0.562	29	0.550	46	0.554
H	3	0.105	26	0.097	113	0.122	142	0.116	25	1.640	111	1.520	136	1.542
I	9	0.206	5	0.222	46	0.149	60	0.164	6	1.864	45	1.567	51	1.602
LA	.	....	31	0.066	..	....	31	0.066	31	0.684	..	....	31	0.684
LB	2	0.116	37	0.113	10	0.118	49	0.114	36	0.875	10	0.566	46	0.808
LC	.	....	48	0.191	16	0.218	64	0.198	46	1.494	16	1.610	62	1.524
LD	.	....	24	0.188	15	0.237	39	0.207	23	1.774	15	1.696	38	1.743
O	5	0.232	50	0.233	124	0.264	179	0.254	48	1.840	124	1.860	172	1.854
MA	6	0.074	..	....	53	0.088	59	0.086	..	....	53	0.729	53	0.729
MB	.	....	13	0.115	67	0.103	80	0.105	13	1.002	65	0.961	78	0.968
MC	4	0.239	6	0.178	75	0.169	85	0.173	5	1.767	76	1.470	81	1.488
MD	4	0.214	4	0.204	110	0.271	118	0.267	4	2.032	109	1.776	113	1.784
30–34	3	0.065	48	0.049	37	0.046	88	0.048	46	1.288	37	0.728	83	1.050
	2	0.100	16	0.076	29	0.123	47	0.108	16	0.695	27	1.004	43	0.889
Ave.	71	0.128	468	0.121	979	0.152	1518	0.141	458	1.286	968	1.267	1426	1.273

True Averages (based on the tons of cane), P_2O_5 per 100 Brix

	Plant	Long Ratoons	Short Ratoons	Average
1924 Crop......................	.0664	.1286	.2277	.1144
1923 Crop......................	.0622	.1062	.2289	.1013

Clarification*

By W. R. McAllep

The results of our previous investigations have been discussed thoroughly enough at these meetings and during factory inspections so that it seems hardly necessary to take up in this paper such subjects as obtaining the maximum increase in purity, the bacteriological considerations involved, the effect of cush cush, etc.

Laboratory work at the Experiment Station during the past year on this project has consisted of: (1) Correlating and studying data secured by H. F. Bomonti on the characteristics of hot clarified juices. (2) Further investigations by H. A. Cook on points developed by Mr. Bomonti's work. (3) Work by Mr. Cook on developing adequate and practicable means for controlling the clarification.

The work by Mr. Bomonti, which has been published in the October *Record*, was undertaken to obtain definite information based on direct experiment on the changes taking place in juice while it is held at high temperatures, that is, from the time it passes through the heaters until lower temperatures are encountered in the evaporators. Comments have been made previously on portions of this work, it having been pointed out that inversion of sucrose was definitely demonstrated in slightly alkaline juices but could not be detected at higher alkalinities. Also that though glucose was destroyed during clarification at alkaline reactions, further destruction was not detected during the digestion of the juice at high temperatures.

On compiling and studying data as a whole, the indications are strong, that from a practical standpoint, one of the most important factors with which we have to deal in factory operation is development of acidity, particularly that taking place at temperatures too high for the development of bacteria.

The term development of acidity is here used to designate a change in the direction alkaline to acid. In addition to development of acidity due to bacterial action, development of acidity takes place in two ways which bear little relation to each other. One is an increase in the total amount of products of an acid nature. The other is an increase in the activity of the acid. The following comments refer to juices not more alkaline than a slight alkalinity to phenolphtha-

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lein, which reaction we consider about as alkaline as is at all practicable in raw cane sugar factories.

In these experiments increase in the amount of acid products was measured by titration with phenolphthalein and litmus. On the basis of phenolphthalein titration, increases in the quantity of acid products proceeded at about the same velocity in alkaline and acid juices. On the basis of litmus titration, there was somewhat of a tendency for it to proceed more rapidly in the more alkaline juices. With both indicators increase in the quantity of acid products took place much more rapidly as temperatures were increased.

Acid acts as a catalyzer in the hydrolysis of sucrose; that is, it causes inversion of sucrose without being consumed. The activity of acid, in other words the hydrogen ion concentration, is therefore of much greater importance in sugar factory practice than the quantity. On the basis of activity, development of acidity at a given temperature proceeds very slowly in the more alkaline juices. In the more acid juices, development of acidity is many times as fast. Also on the basis of activity the development of acidity becomes much faster as temperatures are increased.

It has been the general opinion in factory practice, that alkaline juices become acid faster than the acid juices. Perhaps this is partly due to the fact that litmus has been the indicator commonly used. In the light of data secured during this investigation, this theory is quite contrary to the actual facts, at least so far as the really significant factor, hydrogen ion concentration, is concerned, and within the range of reactions practicable in sugar factory operation.

We have little information on the nature of development of acidity further than that it is a factor of time, temperature, and reaction of the juice. It has been ascribed to the destructive action of lime on glucose, but available data strongly indicate that this cannot be a major factor. It has been noted in the canning industry, where no alkali has been added. It is probably a characteristic of most, if not all, plant juices. Oils also show a similar characteristic, this being particularly noticeable in steam turbine operation.

These data positively indicating inversion of sucrose in slightly alkaline juices, make it appear most probable that inversion in juices proceeds approximately in proportion to the hydrogen ion concentration. Inversion in slightly alkaline juices is not at all inconsistent with our modern conceptions of acidity, neutrality and alkalinity. Neutrality means that hydrogen and hydroxyl ions are present in equal concentrations, not the absence of disassociated ions. In passing from neutrality to alkalinity, that is, from 7 to higher pH values, hydroxyl ions increase with a corresponding decrease in hydrogen ions, the product of the two remaining constant. Thus hydrogen ions are still present even in alkaline solutions, though in greatly reduced quantity. There is little reason to believe that the activity of the remaining hydrogen ions is changed. From this point of view, some inversion would be expected in slightly alkaline juices and indeed it would have been rather surprising had it not been detected.

While destruction of glucose has been noted during the more alkaline clarifications, there has been little, if any, evidence of its further destruction, when the same juices were further digested, at high temperatures.

The above considerations indicate the desirability of as alkaline a clarification as is practicable. While ill effects that might be anticipated from destruction of glucose do not impose a definite limit on the alkalinity, such a limit is imposed by the point at which the maximum increase in purity is secured. This, as a rule, is at about 8.6 pH in the juice after it has passed through the heater. The extent to which development of acidity then takes place is dependent on the temperature and how long the juice is exposed to high temperatures. Under ordinary operating conditions, with the juice leaving the heater at about the above reaction with the temperature approximating the boiling point and the juice not over a couple of hours in the settling tanks, it should leave the latter at from 8.0 to 8.2 pH and the syrup will probably be as alkaline as 7.7 to 7.8. If this is accomplished, any inversion in this part of the process will be absolutely negligible.

This technically desirable procedure cannot be approximated in many cases because of difficulties in filtration due to the large volume of settlings resulting from alkaline clarification and we will not realize the full benefit of our present knowledge of clarification until the problem of filtering a large volume of settlings is solved. However, in such cases we should operate as alkaline as the capacity for filtering settlings will permit, and every effort should be made to obtain maximum efficiency from this equipment.

Mr. Bomonti's work was necessarily planned to give a general idea of what occurs in clarified juices at high temperatures, for little if any exact information was then available on which to base an intensive investigation. Mr. Cook's later work was planned to obtain more precise data on the points that Mr. Bomonti's work developed. From it, we expect to obtain more detailed information on the rate at which acidity develops and the rate at which sucrose is inverted under given hydrogen ion concentration and temperature conditions. More complete data have also been secured at temperatures approximating the boiling point. The results of this more intensive study are in good general agreement with previous work. Evidence of slight destruction of glucose, however, has been found on digesting juices at temperatures approximating the boiling point.

Thorough study and publication of Mr. Cook's data has been temporarily deferred on account of the necessity of developing better means for controlling clarification. Ever since the present clarification investigation was started we have been greatly handicapped because means were not available for definitely expressing the results in terms which could be translated into factory practice. Methods for estimating the hydrogen ion concentrations that are suitable for use in the factory laboratory are greatly needed. The hydrogen electrode, used at this Station is hardly practicable, neither are the usual colorimetric methods using buffer solutions. A colorimetric method has been developed at the Crockett Refinery and operations there are now controlled on this basis. While this is suitable for refinery operations it is not exactly suited to raw sugar factory conditions. In the last few months, Mr. Cook has been working on the necessary modifications. Preparing the color plates required has been a tedious operation, but Mr. Cook has made good progress and we hope to have the method developed so that it can be tried out in factory practice during the coming year. With such a method developed to a satisfactory point, a definite language will be available

for use when clarification or the reaction at which juices should be carried is under discussion.

In the absence of definite means for expressing the results of the investigations in terms that could be translated into factory practice, our original suggestion for approximating what investigation had shown to be desirable clarification practice, was to lime the juice before heating to a pink color with phenolphthalein. The change in reaction in the direction alkaline to acid taking place while the juice is passing through the heater reduces the alkalinity till the reaction of the heated juice is usually within the range where the best results in clarification are secured. This change in reaction varies in different juices. As the really significant factor is the reaction of the juice after heating, the use of phenolphthalein alone does not fully meet the requirements, and some further checks are most desirable. We would now add to our original suggestion the use of two other indicators, thymol blue and cresol red for use in the heated and clarified juice. The juice after passing through the heater should be sufficiently alkaline to give a distinct red with cresol red and a greenish color with thymol blue. It should not be alkaline enough to give a blue color with the latter indicator; at most the color should be a greyish blue. Within this zone the best results in clarification will be obtained. The cresol red will be particularly valuable where the volume of settlings prevents carrying quite this alkalinity. The color change with this indicator passes through orange into yellow as the alkalinity is reduced. We would strongly recommend that when it is impossible to carry the alkalinity at the optimum point, the reaction be maintained alkaline enough so that cresol red gives a distinct orange color in the heated juices.

Since the raw sugar investigation brought out the close relation of good clarification and good refining qualities in the sugar, even more attention than before has been given to applying the results of the clarification investigation during factory inspections, and Mr. Smith has worked toward the same end in factory visits while working on refining qualities of sugar.

Next to insufficient liming, irregular liming has probably been the most serious fault in previous clarification practice. This condition has been greatly improved in the last year or two and now it is quite usual to find the juice fairly even in reaction after going through the heater and mixing in the settling tanks. In many factories, however, different parts of a tank of juice still pass through the heater at widely varying reactions. This condition is objectionable on chemical considerations. Mr. McCleery's observations this year have indicated that it is particularly objectionable from the standpoint of obtaining the clearest juices. His comments on clearness of clarified juice and on this particular phase of the question, based on work during factory inspections follow:

The use of the Kopke turbidimeter has been a great aid in determining what *good* clarification from a physical standpoint really means. This instrument should be used in all our factories and the turbidity figures recorded with the usual routine laboratory data. Larger turbidity figures denote clearer juice than small figures. It is found that if the raw juice and lime are mixed to an even reaction, and if this reaction is at the optimum point demonstrated by our previous work here (faintly alkaline to phenolphthalein, or about 8.8 pH on limed juice before heating), a Kopke turbidity figure of 1.0 can be expected for each .01 per cent P_2O_5 in the mixed juice. In other words with a mixed

juice figure of .035 per cent P_2O_5 and conditions of liming and heating as above, the expected turbidity figure would be about 3.5. Fluming plantations have been found to exceed this figure somewhat. It has been observed that unless the mixed juice and lime milk are thoroughly mixed before heating, the expected clearness of resulting clarified juice is not attained. An efficient means of mixing the juice and lime is essential. Either a compressed air coil, a propeller or set of paddles in the mixing tank under the juice scales will accomplish this. An excellent device for liming and mixing the juice is the one that has been developed at the Oahu Sugar Company. Clarified juice of 3.5 turbidity, usually corresponding to about .035 per cent P_2O_5 in the mixed juice, is clear enough to see through when an ordinary water tumblerful is held toward the light. Mixed juice with more than this amount of phosphoric acid will give clearer juice than the above figure (though with an increased volume of settlings), while mixed juice that is deficient in this respect clarifies poorly, the turbidity decreasing with the increase in phosphoric acid.

On our recommendation, a number of factories having juices low in phosphoric acid, have in a limited way used super-phosphate or double super-phosphate to improve the clearness of the clarified juice. The response to this treatment has been immediate. The use of phosphoric acid compounds in years past had not been particularly successful because of lack of knowledge as to when needed and the quantity. Our work on clarification has included the working out of a phosphoric acid factory control.

Mr. Smith has concluded as a result of his observations that if good efficiency is obtained from filter press equipment and standard filter press capacity is available, it should be possible to lime juices to the optimum point and handle the resulting volume of settlings, provided the phosphoric acid content does not exceed .03 to .04 per cent. Mr. Smith has also concluded after observations at a number of factories that the conditions resulting in clear clarified juice are intimately related if not identical, with the conditions that result in a large volume of settlings. This observation is in excellent agreement with the indications of experimental work.

The Petree Process has now been in use in Hawaii for two seasons. Attempts to appraise the true value of this process are most difficult because of the lack of comparable figures. Adequate treatment of this subject would require detailed analysis of conditions and control figures at each of the factories that is far beyond the scope of a paper such as this. As a result of studies of the Petree Process at each of the factories where it is in opertaion, the writer is of the opinion that notwithstanding the present unsatisfactory state of filtration practice in raw cane sugar factories, the Petree Process cannot compete with the ordinary process when both are properly installed and efficiently operated.

Dr. W. D. Horne's super-defecation process is another patented clarification process that has received considerable attention in the last year or two. The process is now in operation in Cuba. It also is a double settling process, though the juice is not divided as in the Petree Process. The mixed juice is limed to an alkaline reaction, preferably the point giving the largest increase in purity, heated and settled. The settled juice is treated with a phosphate of soda, heated and again settled. This process has some attractive possibilities. Close to the maximum possible increase in purity should be secured and irrespective of the characteristics of the original juice, the clearness of the settled juice can be brought to any desired point, thus securing such advantages as better quality of sugar, less fouling of heating surfaces, etc., that result from securing clear juices. There is an exchange of lime and soda in the ash constituents of the

juice with precipitation of the former. The more soluble sodium salts should have less of a tendency to crystallize out with the sugar, thus reducing the ash and probably the sulphate content of the sugar at a given polarization. Probably, however, this process will be subject to the same difficulty with a large volume of settlings that is encountered in all lime defecation processes when they are operated so that juice of maximum clearness and the maximum increase in purity are secured.

On the whole, filtration is the most serious problem now before us in raw cane sugar factory practice. Our filter presses do not meet technical requirements, nor do they economically separate the soluble from the insoluble in the settlings. Filtration problems, almost, if not quite, as difficult have been satisfactorily solved in other industries, yet no improvement has been made in raw cane sugar factories. Indeed some of our newer presses do not satisfy the requirements in some particulars as satisfactorily as presses the writer had experience with twenty-five years ago. To some extent our lack of progress may be attributed to isolation. To a great extent it is undoubtedly due to failure to fully realize the shortcomings of present equipment in advance of investigations in the last few years.

Kopke centrifugal separators are now being used in an endeavor to solve this problem. As the results secured both in factory practice and in laboratory experiments will be taken up in other papers the writer will not comment further than to say that it is most gratifying to see that serious work is now being done on this problem and that the results should be followed with the greatest interest.

Measurement of Turbidity in Juices*

By Walter E. Smith

In view of the interest in turbidity measurement, some study was made of the various methods available, such as the Kopke turbidimeter, and the observation of carbon lamp filaments, candle flames and cross-lines on translucent paper through a column of liquid in a cylinder. Standard solutions were prepared by coloring distilled water with caramel and adding varying quantities of a kieselguhr suspension.

Ten grams of kieselguhr in 1,000 cc. of distilled water was used as the standard suspension, and varying volumes of this mixture were made up to a volume of 300 cc., together with appropriate volumes of the caramel solution. For convenience, these solutions may be numbered 1, 2, 3 and 4; 1 contained only the kieselguhr suspension and no caramel, while No. 4 approximated the color of the darkest clarified juice ever likely to be encountered.

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Kopke Turbidimeter

The following results were obtained with the Kopke turbidimeter:

	10 cc. Kieselguhr Suspension in 300 cc.	5 cc. Kieselguhr Suspension in 300 cc.
	cm.	cm.
Solution No. 1 (no color)	4.0	6.8
2	3.9	6.7
3	3.8	6.3
4	3.6	6.0

While the effect of color is distinctly noticeable, giving an appreciable difference between the extremes, it seems likely that the difference with the color actually encountered when working with clarified juice would ordinarily be small. The writer has noted cases, however, where the effect of color on turbidity was rather appreciable. With many of the juices found on Kauai, coloring matter present in the juice gives a dark color in alkaline solutions; when such juices are made acid by the addition of a drop or two of acid, there is a very appreciable lightening in color, with a change in turbidity of between 1.0 and 2.0 cm. on the turbidimeter scale.

Nessler Tube Method

A Nessler tube was so arranged that a filament of a light globe could be observed through a column of juice; the cylinder was covered with black paper to exclude outside light. The following results were secured, the figures indicating the number of cubic centimeters of juice in the cylinder at the end point:

Solution No. 1	69
2	68
3	67
4	66

The effect of color is not so noticeable as with the Kopke turbidimeter. Considerable fluctuation in the intensity of light, brought about by introducing varying resistance, did not affect the observation to a greater extent than the normal experimental error.

When using a flash light bulb as the light source, the readings obtained were much higher than with the 60-watt lamp, but not so consistent. This was no doubt due to the greater light intensity per unit of filament length.

When cross-lines were ruled on translucent paper, and placed between the light source and the bottom of the cylinder, the results were consistent and capable of accurate duplication, though the readings were much lower than with the direct observation of the lamp filament. Changes in the intensity of the light had little noticeable effect.

Observations of a candle flame under the Nessler tube were indefinite and therefore unsatisfactory. No clear-cut end point could be obtained, thus making the method unsuited to general use for unskilled observers.

In general, methods based on the observation of a lamp filament might be slightly more accurate than the Kopke turbidimeter, though the latter is probably more practicable as a general method to be used under a wide variety of conditions.

Details for Kopke Turbidimeter

Observations should be made close to a window where there is a uniform illumination, away from overhead lighting and never in direct sunlight. Similar results will be obtained through a rather wide variation of lighting conditions.

The turbidimeter should be held so that the tube is vertical, with the plate touching the side of the cylinder nearest the source of light.

The cylinder used should always be clear, as a stained or dirty cylinder will vary the intensity of illumination.

The end point is reached when the cross-lines on the porcelain plate just disappear from sight, but can again be seen by only a slight raising of the plate. At this point, the finger should be placed firmly over the upper end of the tube, so that no solution is allowed to run out.

The cement used on new turbidimeters will quickly loosen; litharge and glycerine mixed to a paste will re-cement the tube and plate together so that they do not come apart, even in hot juice.

For observation at night, a 60- to 75-watt lamp fixed about 18 inches from the cylinder containing the sample, and about 6 to 8 inches above the surface of the liquid, will give readings which are in close agreement with daylight observations. The exact position of the lamp can be readily determined by making observations in daylight and adjusting the lamp to the point at which similar readings are obtained. The polariscope hood makes a convenient place for this observation at night.

Indicators*

By H. A. Cook

Probably the best known theory of indicators is that of Ostwald, which in substance, is, indicators are acids or bases the undissociated molecules of which have a color different from that of their dissociation products. In this theory it was assumed that the anion of an indicator acid, for instance, has a color different from that of the undissociated molecule.

Cohn (1) defines an indicator as follows: "An indicator, in chemistry, is a substance used for the purpose of affording ocular evidence regarding the condition of acidity, alkalinity or neutrality existing in a liquid; . . . "

More in accord with the modern conception of acidity and alkalinity is the following definition as given by Prideaux (2): "In its broadest sense the chemi-

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cal indicator may be defined as a substance which, when added in small quantities, shows the appearance or disappearance of a chemical individual (ion or molecule) by a conspicuous change in color . . . . The study of indicators is chiefly interesting from three points of view; first, there is the question of their sensitivity, i. e., the accuracy with which they can be used for titrations and colorimetric estimations. Second, in the investigation of the H^+ and OH^- equilibria in which they play a part. Third, the relation between color change and constitution."

In this paper it is not proposed to go into the various factors which formulate a theory of indicators. We are concerned chiefly with the first and second points brought but by Prideaux in the above definition of indicators, i. e., their sensitivity and their use in determination of the H^+ and OH^- equilibria.

During the past few years, the conception of acidity and alkalinity has undergone a radical change. There is no necessity here of going into the details of the ionic theory or a discussion of the dissociation of acids or bases. It has been thoroughly demonstrated that there is a dissociation of the H ions and the degree of this dissociation is the important consideration in acidimetry.

In all aqueous solutions there are at all times both dissociated and undissociated ions. These ions in a solution are dissociated to different extents. The modern conception is that there is a constant movement, attraction and repulsion, between these ions which are electrically charged, the hydrogen ions carrying a positive charge and the hydroxyl ions a negative charge. It therefore, is a question of the activity of the hydrogen ions with which we are concerned.

The relation of the terms, hydrogen ion concentration, pH values, total acidity, etc., were well covered in a paper presented at this meeting last year by Mr. King (4). This relationship has been further discussed in the October number of the *Record*, this year, in a paper by H. F. Bomonti and W. R. McAllep entitled, "Characteristics of Clarified Juices at High Temperatures."

Until very recently all reference to reaction values, where any definite values were expressed, have been in terms of total acidity or alkalinity. In the beet sugar industry these terms have had a quite definite meaning and are usually expressed as "gms. CaO per 100 cc." In cane sugar practice there has not been this close an expression of the values. Where definite values were assigned the expression was usually placed in terms of cubic centimeters of some normality of acid or alkali. The more common expression found is "slightly acid to litmus" or "slightly alkaline," often the indicator used was not mentioned. The expression of results at the Experiment Station has been "gms. CaO per 100 cc."

This loose application of the terms acidity and alkalinity has resulted in considerable confusion. It has made it extremely difficult to correlate the results obtained by one factory with those of another or of one man's work with another. The results of much valuable research work has been lost due to inability to interpret the results into values that had definite meaning.

The introduction of the ionic theory with a better understanding of the meaning of the terms hydrogen ion concentration and pH values and the consequent "better definition of degree in 'acidity' or 'alkalinity,' together with improved means of measuring these values, has developed among scientific men in general

an appreciation of how indefinite were those old terms 'slightly acid,' 'distinctly alkaline' and 'neutral.' There is now a clear recognition of the distinct difference between quantity and intensity of acidity and for each aspect there may be given numerical values admitting no misunderstanding." Clark (3).

Aside from the above considerations, it might be well to briefly touch upon some of the recent developments of research work at our Experiment Station which show the desirability of expressing these values in definite terms.

Investigations on clarification carried out by Mr. Bomonti at the Experiment Station demonstrate that the best results in clarification and the largest increase in purity were secured by liming the cold raw juice to a faint color to phenolphthalein. At that time a hydrogen ion apparatus was not available at the Station and it was believed that a reaction existed in the clarified juice which could be expressed in terms of titratible alkalinity to litmus as an indicator. Later, it was found that this relation did not exist. It has since been found that liming to this point corresponds to 8.8 pH.

Investigations on the digestion of juices at high temperatures, by Mr. Bomonti, thoroughly demonstrates that there is a definite reaction, below which juice will not keep, without inversion, over a period of 22 hours. This reaction is directly related to hydrogen ion concentration or pH values and does not have any relation to total acidity or alkalinity.

More recent investigations, by the writer, substantiate Bomonti's findings and will probably establish more definitely the hydrogen ion concentration at which inversion takes place in clarified juices. We also expect to be able to establish the rate of inversion at the different hydrogen ion concentrations and to establish the rate at which clarified juices become acid at different initial reactions and at different temperatures.

It is a definitely established fact that there is a narrow margin of hydrogen ion concentration at which the maximum results in clarification are obtained. We believe that we are now prepared to state that there is a definite hydrogen ion concentration below which inversion may be detected in clarified juices. The inversion of sucrose in clarified juices begins at a much more alkaline reaction than was heretofore realized. The inversion of pure sucrose has, for years, been used as a measure of hydrogen ion concentration, but it had not been established that there was just as definite a relationship existing in clarified juices.

With these facts in view, it is entirely advisable to place the reaction control of our Hawaiian factories on a uniform and intelligible basis.

Cane juice can roughly be described as a complex aqueous solution containing sugar. This solution therefore contains both hydrogen ions and hydroxyl ions. The raw juice contains an excess of hydrogen ions and the clarified juice usually contains an excess of hydroxyl ions.

We are directly faced with two problems in the clarification process; first, the purification of the complex aqueous sugar solution to the extent that the greatest amount of impurities may be eliminated from the juice so that the highest possible recovery of sugar may be obtained; second, to have this clarified juice at such a reaction that the minimum of inversion will result through the process.

There have been many conflicting statements made as to how acid a juice may be allowed to become before there is any danger of loss by inversion. It has been stated by some authorities that there is practically no danger of inversion in running the house "slightly acid." Here is another instance of the looseness with which the term acid is used, for most of these authorities do not state what is meant by the term "acid house," that is, whether they mean acid to litmus, phenolphthalein or true neutrality. Other authorities have definitely stated that the juice can be carried "neutral" or "slightly acid" to litmus without loss from inversion. We have found at the Experiment Station that inversion does take place in juices that are definitely alkaline to litmus and even definitely alkaline to true neutrality.

Placing the chemical control of the sugar factory on a hydrogen ion concentration basis involves means for this determination. There are two generally used methods for this purpose. First, the electrolitic measurement by means of the hydrogen electrode. This method is, for all commercial purposes, the most rapid, convenient and accurate but is not yet adaptable for general use in sugar house laboratories. On this account it will not constitute a part of this paper. Further information can be obtained from numerous sources, notably, "The Determination of Hydrogen Ions," by W. Mansfield Clark, or the determination can be demonstrated at this Station.

The second method for this determination is known as the colorimetric method. This method is based on the use of indicators.

The use of an indicator method for the determination of hydrogen ion concentration involves a choice of indicators. Indicators should be selected in reference to their sensitivity, their freedom from salt and protein error, their definiteness of color change and the proper pH range of the indicator. Several indicators have been tried out at this Station but for our use those proposed by Clark & Lubs (5) have been found to be the most useful.

The distinctive advantages of the indicator method are the ease and the rapidity with which the approximate hydrogen ion concentration of a solution can be measured. The introduction of improved indicators, the charting of their pH ranges, better definition of degree in "acidity," or "alkalinity," make this method a desirable one for our purpose.

Litmus and phenolphthalein have been the almost universally used indicators for sugar house control. Litmus has played an important role in acidimetry and should be given full credit, but its use in other than the cane sugar industry has now almost become obsolete. It is not a reliable indicator for sugar house control. There are several reasons for this statement, among them the following: The color change takes place through a pH range of 4.5 to 8.3, the so-called neutral point to litmus is approximately 6.3 pH. These two facts in themselves are against the use of litmus for our purpose. The pH range is so broad that the color change is very indefinite and the approximate pH value of any hue cannot be definitely determined. The neutral point is so far on the acid side of true neutrality that this point is valueless. True neutrality is pH 7.0. There are two other facts which make the use of litmus objectionable, i. e., the source and degree of purity of the product. Litmus is a complex of many compounds, chief among

which are azolitmin, erythrolitmin, erythrolein and spaniolitmin. Of these, azolitmin is the most important, but, the azolitmin of commerce is of uncertain composition. The composition of the different preparations varies with the source and also with the extent of the action of alkali and air upon the crude material. Products secured on the market are of variable purity and seldom is a pure product obtained. For the determination of pH values, indicators of the highest purity must be used.

Phenolphthalein is of comparatively recent use in Hawaii and is the best indicator yet found for its purpose. It is a one color indicator and has a pH range from 8.3 to 9.8, depending a little on the concentration used. The concentration used in the clarification investigations was 0.1 per cent. At this concentration it first shows color at about 8.3 pH in colorless buffer solutions. In cane juice it does not show color till about 8.6 to 8.8 due to the natural color and turbidity of the juice. This appearance of color is quite definite and regular in different juices.

There are several colorimetric methods in use for the determination of hydrogen ion concentration values; these are all based upon the use of buffer solutions and appropriate indicators. Only what is known as the spot test method will be described in this paper. For further information the reader is referred to the references already cited. The spot test, as far as can be learned, was introduced by L. D. Felton (6). This method was originally adopted for biological or pathological use where only small quantities of liquid were available. The method has since come into quite general use. The comparisons are made with buffer solutions of known value.

The spot test method is now used for the control of some of the sugar refineries on the mainland and is also used by a few of the mills in Porto Rico. H. Z. E. Perkins (7) has described the method in use at the American Sugar Refinery at Chalmette, La. A previous article was published by Brewster and Raines (8) on "Control of Reaction in Sugar-House Liquors." Buffer solutions were used as the basis of these comparisons. Crockett Refinery was probably the first to apply the spot test method without the use of buffer solutions.

The use of buffer solutions carefully standardized by means of the hydrogen electrode is undoubtedly the correct procedure for colorimetric determinations.

Against all colorimetric methods there are distinct drawbacks for their use in plantation laboratories. It must be understood that the colorimetric method, at its best, is an approximation of the true value. With indicators and methods so far developed, results are secured which should check to within 0.2 pH. Adaptions of the method can be used which are of distinct value and without doubt far superior to the present method of expressing reaction values.

One of the main objections to the use of the regular colorimetric method is the use of buffer solutions. Buffer solutions are troublesome to prepare. Very pure chemicals must be used; these must be repurified by several recrystallizations. Several sets of buffer solutions have been made up at the Station following the directions of Clark (3), but have not given the correct values. In nearly all cases the solutions have had to be adjusted considerably before use. This fact may be due to the purity of the chemicals used or to other reasons. M/5 NaOH

is especially difficult to prepare and keep free from CO_2. The prepared buffer solutions should always be checked by means of the hydrogen electrode before use.

Another objection to the use of buffer solutions is the fact that they cannot be counted upon to retain their values for any definite length of time, even though it is, of course, always assumed that precautions are taken to avoid contamination and maintain perfect cleanliness in operations. It is important that the buffer solutions be frequently checked with the hydrogen electrode.

It is desirable, therefore, to develop a method, if possible, by which the advantages of the colorimetric method can be retained and yet avoid the use of troublesome buffer solutions. The only way we have found it possible to do this is to prepare standard color charts which are in agreement with standard buffer solutions with the indicator added.

Crockett Refinery, realizing the need for more definite control of the refinery liquors, developed a modification of the spot test method by preparing a color chart for the comparisons. The range of indicators in this chart is not adaptable to our use, but we are working along the same line and hope to develop a chart for use on our plantations.

Twigg Smith first reproduced the colors with oil paints on canvas. McCleery and Smith used charts prepared from these colors for a part of this past year and secured quite good results. However, we desired to improve these charts and have been endeavoring to reproduce the colors by means of dyes on celluloid. This gives a more satisfactory color than does the oil and canvas. There have been numerous difficulties to overcome in preparing these charts and the work has taken considerably more time than was originally anticipated. However, we fully expect that the results secured from their use will fully repay the time and effort expended.

There are certain conditions which must be conformed to in using this method. In practice, conditions must be comparable to those under which the standards were prepared. Indicators of the highest purity must be used. The same concentration of indicator must be used. The depth of indicator color in the spot plate must be the same, therefore, spot plates must be used which duplicate those from which the standards were prepared. The same amount of indicator and sample must be used as was used in preparing the standards. Cleanliness must be observed.

Equipment Required

Eight oz. glass stoppered bottles for stock solution of indicators; 1 or 2 oz. dropping bottles for use with the indicators. The best type of dropping bottle for this purpose is the regular pathological dropping bottle. A substitute may be prepared from a small, fairly large-mouth bottle, fitted with a cork through which a medicine dropper is inserted. A spot plate with depressions of the following dimensions: 7 mm. depth and 20 mm. in diameter. Steps have been taken to assure a supply of these plates. 1 cc. pipettes.

Method of Determination

Four drops of the appropriate indicator are placed in the depression of the spot plate; to this is added 1 cc. of the sample. A moment should be allowed for the dissemination of the indicator through the sample. Stirring is not advisable.

This color is then compared with the colors of the chart and the pH value of the color on the chart with which it coincides is taken for the pH value of the sample.

It is desirable that the readings be checked by overlapping indicators. For instance, cresol red covers most of the range of phenol red, and thymol blue overlaps a large portion of the higher range of cresol red.

Dilution

Where the color or turbidity of the juice interferes with the color of the indicator, dilution of the juice may be resorted to. In a well buffered solution, especially one around the neutral point, pH 7.0, dilution affects the pH value to a very slight extent. It has been found that there is a small dilution error in cane juices. This error is slight around the neutral point. The error increases the farther the value lies in either direction from the neutral zone amounting to 0.1 to 0.3 pH. Dilution does not affect the pH value as determined colorimetrically to quite the extent it does readings obtained by the electrode. A 1-3 or 1-5 dilution will be sufficient for nearly all cases.

For the purpose of making dilutions it is well to use test tubes calibrated for this purpose. This calibration need not be especially accurate. It is best to have the test tubes marked at 5 cc. and 20 cc. for the 1-3 dilutions and at 5 cc. and 30 cc. for the 1-5 dilutions. The tube can be rinsed out with a portion of the sample, filled to the lower line with the sample and then to the upper line with distilled water.

Some plates have substances on the surface of the plate or in the glazing which cause some degree of ionization. Such a condition will have to be overcome and is usually accomplished by letting a solution of sulfuric-cromic acid stand on the surface of the plate for an hour or so, then washing thoroughly with distilled water. It is well to follow this procedure every few days.

Indicators and Their Concentration for Use

To cover the full range of reactions of the juices found in the sugar house several indicators will be required. The following indicators will usually cover the range through raw juice to the clarified juice; brom cresol purple, brom thymol blue, phenol red, cresol red, thymol blue and phenolphthalein. All of these indicators are not necessary, however, in factory practice. In practice, two or possibly three indicators will serve all purposes. These will probably be: phenolphthalein together with phenol red, cresol red or thymol blue.

The preparation and concentration of the indicators is as given by Clark (3) excepting for phenol red and cresol red. With these two indicators a higher concentration was found advisable. The method of preparation as given below is taken directly from Clark:

"For the preparation of these stock solutions one decigram (0.1) gram of the dry powder is ground in an agate mortar with the following quantities of N/20 NaOH."

Indicator	Color Change	pH Range	cc. N/20 NaOH
Brom cresol purple	Yellow-purple	5.2-6.8	3.7
Brom thymol blue	Yellow-blue	6.0-7.6	3.2
Phenol red	Yellow-red	6.8-8.4	5.7
Cresol red	Yellow-red	7.2-8.8	5.3
Thymol blue	Yellow-blue	8.0-9.6	4.3

Clark advises making these up to 25 cc. with distilled water for stock solutions and diluting in the dropping bottles to a concentration of .04 per cent, 0.02 per cent for phenol red and cresol red. We have found that it is just as well to make immediately up to 250 cc. with distilled water thus making in all cases a .04 per cent solution.

Phenolphthalein should be made up in .1 per cent solution. The salt should be dissolved in alcohol and then diluted with water so that the alcoholic strength is approximately 50 per cent by volume. The acidity of the alcohol should be neutralized by adding N/100 NaOH to a slight pink then adding one drop N/100 sulfuric acid.

McCleery and Smith both experienced some difficulty in the use of brom thymol blue. They obtained results which averaged about .8 pH low. Until we have determined the cause of this, we are not advising the use of this indicator. The range is lower than is usually needed for factory practice so that this indicator is not needed. We have found, too, that we can extend the range of phenol red a little lower and thus overlap with brom cresol purple for the lower range.

For conditions where the P_2O_5 content of the juice is such that the liming can be carried to the point advised in clarification practice, phenolphthalein is the best indicator to use. The cold raw juice should be limed to a slight color to phenolphthalein. This will give a reaction close to 8.8 pH. The clarified juice from this liming should not fall below 8.0 pH. The reaction of the clarified juice should be as carefully controlled as the reaction of the raw limed juice. For this point either cresol red or phenol red can be used.

If for any reason it is not possible or desirable to carry the liming to the extent above stated it is possible to establish a definite reaction and control it by the use of one of the above indicators. If a point is used lower than that which has been found advisable it should be made as high as possible and the control maintained as carefully as at the higher point. As stated before, litmus should not be used for the basis of control, for a definite reaction cannot be established by its use. If it is desired to lime between the litmus value and phenolphthalein, a neutrality reaction of 7.0 can easily be established with phenol red by liming to a faint pink. If 7.5 is desired a faint pink to cresol red will give this point. If 8.0 or 8.2 is wished, it can be secured by liming to a distinct red to cresol red or a faint blue to thymol blue. Where a factory wishes to lime to a faint alkalinity to litmus, or an acid reaction, it can be secured much more definitely by using brom cresol purple and liming to a faint purple. The above considerations can be applied directly in the factory.

The color chart is intended, primarily, for the use of the chemist in the laboratory. It is important that a close control of the mill juices be maintained. By this method a record of the reactions can be kept. The reactions and the terms of expressing them will be a definite language. It will be possible to make direct comparisons of the work of one mill with another and the chemist will be able to check up his practice with that of others and with clarification investigations.

It is not claimed that the adoption of this method will be a cure-all for the troubles in the cane sugar practice. There will undoubtedly be difficulties experienced in using the method and in some cases difficulty in matching colors. As stated before, the use of indicators is only an approximate method. It will, however, be a step far in advance of present practice and will eliminate much of the guesswork in factory control.

There is much to be learned about indicators and their use. New and better indicators will undoubtedly be developed and better methods of control will follow. There is a great need for closer control of the reaction of the juices in the sugar house than has been generally realized. We must take advantage of the best methods available and realize the importance as well as the limitations of their application.

It is admitted that the use of this method will require a little more attention to details, but it is being done in one of the Hawaiian factories and in several elsewhere, so it can be done here. In all processes best results are obtained by attention and effort. This extra attention, once it is established, will not be marked in its requirements but results are bound to be manifested.

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A Mathematical Analysis of Boiling Systems*

By Walter E. Smith

In this analysis, the writer has sought to compare a number of boiling systems, using as a basis of comparison the weight of gravity solids in massecuite per unit of gravity solids in syrup.

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It is evident that the system capable of producing its sugar from the smallest quantity of massecuite will be the most economical from the standpoint of fuel; it also seems probable that such a system will produce sugar of the best refining qualities, all other conditions being equal.

The production of good filtering sugar is dependent on securing a minimum concentration of what we have termed non-settling matter in massecuite from which the commercial sugar is produced. For a given concentration of non-settling matter in syrup, the minimum concentration in massecuite must obviously be produced under the conditions which produce the smallest quantity of massecuite, since the increase in quantity of massecuite can only be brought about by boiling back additional quantities of molasses having a much higher non-settling matter concentration than the syrup; this, of course, must result in an increase in the non-settling matter concentration of the massecuite and be reflected in a reduced filtration rate of commercial sugar.

The assumptions used in the calculations that follow approximate results actually attained in normal factory practice. It does not follow, of course, that the results indicated by these calculations will hold good for factories where the operating conditions vary to any extent from the assumptions used, but it is probable that similar relationships will exist between the various boiling systems under other conditions, and the same methods of calculation may be applied. The calculations are based on gravity purities, conversion from apparent to gravity purities being affected by assuming a difference of 0.8 at 86.0 apparent purity, and 1.0 for each 10.0 points thereunder, giving 57.1 gravity for 54.0 apparent purity of low grade massecuite. Molasses is assumed at 36.0 gravity purity; the commercial sugar is taken at an average of 97.0 polarization, with .25 deterioration factor. Massecuite yield has been calculated on a basis of a difference of 20.0 apparent purity, or 18.0 gravity purity, between massecuite and molasses. In considering double purging, it has been thought feasible to raise 70 apparent purity No. 2 sugar to 90 apparent purity when producing a molasses of 54.0; in actual practice, no difficulty has been experienced in raising No. 2 sugar 16-17 points with a molasses of 48-50. By a slightly greater dilution of the magma or the use of a small quantity of wash water at the centrifugals, the double purged sugar could be brought to a purity of 20 points higher than the original low grade sugar without difficulty. When the molasses has been held to 50 apparent purity, the double purged sugar has been assumed only 16.0 points higher than the magma.

Two-Boiling System

In the so-called "two-boiling system," the commercial sugar massecuite consists of a mixture of syrup, remelt, and No. 1 molasses, at such purity that the molasses from this massecuite is suitable for low grades. The factors affecting the quantity of massecuite are purity of syrup and the purity to which the low grades are reduced (assuming that the massecuite will remain 20 points higher than the No. 1 molasses). If the purity of the remelt remains constant, decreasing the purity of the low grades brings about a marked increase in the quantity of massecuite; if, however, we assume the purity of remelt to also vary with the

low grade massecuite purity, that is, to be for example 16.0 higher than the low grade purity, the sum of commercial sugar massecuite and low grade massecuites remains very nearly constant. This system will show to worst advantage where the purity of low grades is low—50 to 52—with the usual drop of 20.0 from massecuite to molasses. Where a sugar of high polarization is produced with this system, it is usually attained by washing in the centrifugals; apart from its effect on the keeping quality of sugar, this is likely to raise the molasses purity, thus further increasing the quantity of massecuite per ton of sugar.

Pioneer System of Boiling

The so-called "Pioneer system" of boiling is based on a principle entirely different from that of the two-boiling system. In the Pioneer system, the first strike is boiled of syrup and remelt, no molasses from previous boilings being taken back; all the molasses from this so-called "A" strike is taken into the following strike, designated as "B." Under certain conditions, the molasses from the "B" strike may be of proper purity for low grades; if not, it is again taken in, the third strike of the series being designated as "C." Normally, the "C" molasses will be suitable for low grade massecuite, and it is not often necessary to boil a fourth, or "D" strike.

The following summary showing No. 1, No. 2 and total massecuite per unit of gravity solids in syrup will serve to show the effect of the various factors and conditions on the gravity solids in massecuite per unit of gravity solids in syrup:

	(Syrup 86.8 Gr. Purity; Sugar 97.0 Pol.; 98.04 Purity)	Massecuite with 54 Pur. Low Grade 1	2	Total	Massecuite with 50 Pur. Low Grade 1	2	Total
	"Two-Boiling System"						
1	70 A. P. Remelt	1.77	.43	2.20	1.99	.37	2.36
	"Pioneer System"						
2	70 A. P. Remelt (A & B only)	1.57	.43	2.20	1.73	.37	2.10
3	79 A. P. Remelt (A, B & C strikes)	1.68	.35	2.03	1.63	.31	1.94
3a	75 A. P. Remelt (A, B & C strikes)	1.74	.37	2.11	....	...	....
3b	75 A. P. Double purged to 90 A. P.	1.58	.37	1.95	....	...	....
3c	79 A. P. Remelt	1.51	.34	1.85	....	...	....
3d	79 A. P. Remelt	1.52	.34	1.86	....	...	....
3e	79 A. P. Remelt	1.54	.34	1.88	....	...	....
3f	70 A. P. Double purged to 90 A. P.	1.48	.43	1.91	....	...	....
	(In systems 3c-3f the B strike is only mixed to desired purity, and not to fixed volume, as explained in later paragraph.)						
4	70 A. P. Remelt double purged to 90 A. P.	1.59	.43	2.02	1.59	.37	1.96
5	D. P. Remelt (90) with 2A and 1B	1.51	.43	1.94	1.50	.37	1.87
6	Same as 5, except no syrup in B	1.55	.43	1.98	1.54	.37	1.91

In systems 2-3b, the mixtures of the various products have been made in such a way as to meet the conditions of actual practice, that is, that each strike shall be of the same volume—a full pan. This is, of course, required by considerations of economy and simplicity of practice, since either A, B or C strikes are based interchangeably on the same foundation of seed and syrup from a central grain-

ing pan. In effect, however, this may cause an increase in the massecuite per unit of solids in syrup as can be readily seen from the fact that with 79 apparent purity remelt, using three strikes to reduce the molasses purity, the quantity of massecuite is actually 0.11 greater than where only two strikes are required as in "2," with 70 apparent purity remelt.

The reason for this lies in the fact that in systems 3 and 3a, the average massecuite purity is actually lower than in 2; it is of interest to note that in the systems tabulated, the quantity of massecuite varies directly with the average purity of massecuite.

In systems 3c-d-e, the usual procedure has not been followed. Instead of producing equal quantities of A, B and C massecuite, the A molasses is mixed with sufficient syrup to make a B strike of such purity that with a 20 point drop, the molasses will be suitable for low grades. In 3c, the A strike takes in neither remelt nor molasses; the B strike is equal to 72 per cent of the A strike, and the A sugar comprises 65 per cent of the total commercial sugar. In 3d, sufficient No. 2 sugar is taken into the A massecuite for seed, and the B massecuite made up as before; in this case, the B massecuite decreases to 71.5 per cent, while the A sugar remains constant at approximately 65 per cent. In 3e, practically all of the remelt is taken into the A strike; the B massecuite drops to 69 per cent, with the A sugar a fraction over 65 per cent.

In system 3f, where 70 apparent purity remelt is double-purged and the B massecuite is boiled at suitable purity to give molasses ready for low grades, the B massecuite is less than 60 per cent of the A massecuite, with the A sugar comprising 70 per cent of the total production. The principle of making the respective volumes of A and B massecuite not necessarily equal offers some saving of massecuite, though it does introduce the complication of building a suitable grain in less than a full pan. An apparently satisfactory compromise is found in system 5, wherein with double-purged remelt, it is found possible to boil only one B strike for two A strikes. Here the A sugar comprises 75 per cent of the total commercial sugar produced, a condition very close to the ideal.

The system capable of producing sugar of highest refining quality would, of course, be a system of straight boiling, wherein all the commercial sugar was crystallized from a massecuite containing no molasses. For example, we could make up the first massecuite from syrup, double-purged remelt, and 96 purity sugar coming from the B massecuite; the molasses from this strike would be boiled to grain, and from this a sugar of 96 purity produced, to be remelted or used partly as seed for the first strike. Calculating on a basis of producing 98.0 polarization sugar, this system would contain 1.81 tons gravity solids per ton of gravity solids in syrup in the A and B massecuites; this figure is only slightly higher (0.04) than the two-boiling system, and has the advantage of producing the best sugar obtainable with any system of boiling. It is, however, 20 per cent higher in solids in massecuite than the method producing two A's and 1 B strike, with double-purged remelt.

Summary

Assuming that filtrability of commercial sugar is dependent on the concentration of non-settling matter in the massecuite from which it is produced, we may

conclude that this concentration may be further affected by boiling methods. The system requiring the least quantity of massecuite per unit of solids in syrup should give the best results, since any addition to the quantity of massecuite can only be made by additional boiling back of molasses, which in turn will increase the non-settling matter concentration of the massecuite. The system producing the least massecuite is that which has the highest average massecuite purity.

From this standpoint, the "two-boiling" system is the most objectionable, since this gives the lowest possible massecuite purity and the highest amount of massecuite per ton solids in syrup.

The first step in the direction of straight-boiling—the ultimate ideal—is the Pioneer system, which produces part of its sugar from strikes of high purity; the last strike of the series is equal to that found in the "two-boiling" system, but the sugar produced in the other strikes clearly represents an improvement. Present practice, however, in seeking to apply the principles in a manner most easily followed, and least subject to confusion, makes A, B and C massecuite of equal quantity; it can be shown by calculation, however, that less massecuite is produced if the massecuites of lower purity are reduced to the minimum. For example, with syrup of 86.0 apparent purity, double-purged low grade sugar of 90 apparent purity, and 54.0 apparent purity low grades, a system can be followed which will produce two A strikes to one B strike—securing 70 per cent of the total commercial sugar from A strikes.

Methods of Calculation

The following scheme of calculation will show the methods used in arriving at the results indicated, and may serve as a guide to be followed in calculating similar data for a different set of factory conditions.

"TWO-BOILING SYSTEM"

Assumptions:

Syrup	86.8	Gravity	Purity	
Final Molasses	36.0	"	"	
Commercial Sugar	98.04	"	"	(97.0 Pol.)
Remelt (No. 2 Sugar)	72.4	"	"	
No. 1 Massecuite	76.0	"	"	
No. 1 Molasses	57.1	"	"	

By formula, the total yield of commercial sugar will be:

$$\frac{98.04\ (86.8 - 36.0)}{86.80\ (98.04 - 36.0)} = 92.486\%.$$

For each 100 tons of gravity solids in syrup, we will then have:

86.8 tons sucrose $\times$ .92486 = 80.28 tons sucrose in commercial sugar, with the following distribution of sucrose and solids in syrup:

	Sucrose	Gravity Solids
Commercial Sugar	80.28	81.88
Final Molasses	6.52	18.12
Syrup	86.80	100.00

Turning our attention next to the low grade massecuite, we find that for our assumed conditions the yield of No. 2 sugar at 72.4 gravity purity is:

$$\frac{72.4\ (57.1 - 36.0)}{57.1\ (72.4 - 36.0)} = 73.5\%.$$

That is, 73.5 per cent of the sucrose in low grade massecuite is returned in the No. 2 sugar, while (100 — 73.5 = 26.5%) is eliminated with the molasses. In other words, the sucrose in final molasses is equal to 26.5 per cent of the weight of sucrose in No. 2 massecuite; since the sucrose in final molasses is 6.52 tons per 100 tons of gravity solids in syrup, the quantity of sucrose in No. 2 massecuite is:

$$\frac{6.52}{.265} = 24.60 \text{ tons sucrose.}$$

$$\frac{24.60 \text{ tons sucrose}}{.571 \text{ (Gravity Purity)}} = 43.08 \text{ tons gravity solids.}$$

The No. 2 massecuite is therefore distributed as follows:

	Sucrose	Gravity Solids
No. 2 Massecuite	24.60	43.08
Final Molasses	6.52	18.12
No. 2 Sugar (Remelt)	18.08	24.96

The base of the No. 1 massecuite then becomes:

	Sucrose	Gravity Solids
Syrup	86.8	100.00
No. 2 Sugar	18.08	24.96
Base (83.93 Gravity Purity)	104.88	124.96

We must now add sufficient No. 1 molasses of 57.1 gravity purity to reduce this base to 76.0 gravity purity; the quantity required is arrived at by formula:

$$\frac{83.93\ (76.00 - 57.10)}{76.00\ (83.93 - 57.10)} = 77.794\%.$$

This means, then, that 77.794 per cent of the sucrose in the finished massecuite at 76.0 gravity purity is contained in the base of the No. 1 massecuite. Then, 104.88 ÷ 0.77794 gives 134.82 tons, the quantity of sucrose in the finished massecuite; at 76.0 gravity purity, this is equal to 177.39 tons of gravity solids.

The composition of the No. 1 massecuite is then as follows:

	Sucrose	Gravity Solids
Syrup	86.80	100.00
No. 2 Sugar	18.08	24.96
No. 1 Molasses	29.94	52.43
No. 1 Massecuite	134.82	177.39

The yield of the No. 1 massecuite is:

$$\frac{98.04\ (76.0 - 57.1)}{76.00\ (98.04 - 57.1)} = 59.553\%.$$

The No. 1 massecuite is therefore distributed as follows:

	Sucrose	Gravity Solids
Commercial Sugar	80.28	81.88
No. 1 Molasses	54.54	95.51
No. 1 Massecuite	134.82	177.39

The quantity of No. 1 molasses used in the No. 1 massecuite must be deducted from the total No. 1 molasses produced, since this quantity may be considered as having been "borrowed" from process; in actual practice, this amount is in circulation in the No. 1 massecuite.

	Sucrose	Gravity Solids
Total No. 1 molasses produced	54.54	95.51
Used in No. 1 massecuite	29.94	52.43
No. 1 Molasses to Low Grades	24.60	43.08

This quantity agrees with our previous calculation. The total sucrose introduced in syrup is accounted for in commercial sugar and final molasses, thus balancing the system.

SUMMARY

		Per Unit Gravity Solids in Syrup
No. 1 Massecuite	177.39	1.77
No. 2 Massecuite	43.08	.43
Total	220.47	2.20

PIONEER SYSTEM

Assumptions:

Syrup	86.8	Gravity Purity
Final Molasses	36.0	" "
Commercial Sugar	98.04	Purity (97.0 Pol.)
"A" Sugar	98.69	" (98.0 Pol.)
Remelt (No. 2 sugar)	72,4	Gravity Purity
Low Grade Massecuite	57.1	" "

The quantity of low grade massecuite and remelt will remain the same as in the previous system, since the factors affected by these quantities have not been changed.

In this system, we assume the use of a small amount of seed in the A massecuite, which is therefore made up as follows:

	Sucrose	Gravity Solids
Syrup	86.80	100.00
No. 2 Sugar	4.03	5.56
(86.05 Gravity Purity)	90.83	105.56

The yield of this massecuite is:

$$\frac{98.69\ (86.05 - 68.05)}{86.05\ (98.69 - 68.05)} = 67.376\%$$

	Sucrose	Gravity Solids
"A" Sugar	61.20	62.01
"A" Molasses	29.63	43.55
Total A Massecuite	90.83	105.56

The total No. 2 sugar produced as a result of the use of 100 tons gravity solids in syrup in "A" massecuite would be:

	Sucrose	Gravity Solids
No. 2 Sugar due Syrup in "A"	18.08	24.96
Actually used in "A"	4.03	5.56
Excess No. 2 sugar to be used in "B"	14.05	19.40

The production of No. 2 sugar under the assumed conditions is 24.96 tons solids per 100 tons gravity solids in syrup; in order that the system will balance, this quantity must therefore be used, or this proportion maintained between syrup and No. 2 sugar.

The "B" massecuite is made up, then, of the "A" molasses, the excess remelt not utilized in "A," and sufficient syrup and remelt to bring the quantity of "B" massecuite to approximately the same figure as that for "A." This gives us then, the following composition of "B" massecuite:

	Sucrose	Gravity Solids
"A" Molasses	29.63	43.55
Excess remelt due syrup in "A"	14.05	19.40
Syrup	29.87	34.41
Remelt due this syrup	6.22	8.59
"B" Massecuite (75.29 G. P.)	79.77	105.95

Before calculating the yield of this massecuite, we must determine the purity of the "B" sugar, as follows:

From the syrup used in the two massecuites, the total yield will be:

	Sucrose	Gravity Solids
Total	107.90	110.06
"A" Sugar produced	61.20	62.01
"B" Sugar by Difference (97.20 Purity)	46.70	48.05

The yield of the "B" massecuite will therefore be:

$$\frac{97.20\ (75.29 - 57.10)}{75.29\ (97.20 - 57.10)} = 58.562\%.$$

	Sucrose	Gravity Solids
"B" Sugar	46.70	48.05
"B" Molasses	33.07	57.90
"B" Massecuite	79.77	105.95

SUMMARY

(134.41 Tons G. S. in Syrup)		Per Unit Gravity Solids in Syrup
"A" Massecuite	105.56 Tons	....
"B" Massecuite	105.95 Tons	....
Total No. 1 Massecuite	211.51 Tons	1.56
No. 2 Massecuite	57.90 Tons	.43
Total		1.99

STRAIGHT BOILING

Assumptions:

Syrup	86.8 Gravity Purity
Sugar	98.0 Polarization (98.69 Purity)
No. 2 Massecuite	57.1 Gravity Purity
Final Molasses	36.0 " "
Low Grade Sugar:	
Original	72.4 " "
Double Purged	90.4 " "

(In this system, the drop between massecuite and molasses is taken at only 18.4 apparent purity, or 16.6 gravity purity.)

The total yield in this system is found to be 79.97 tons sucrose, and 81.03 tons gravity solids per 100 tons gravity solids in syrup. By the methods illustrated in the previous series, we find that the low grade sugar will yield 57.57 per cent of its sucrose in the form of 90.4 gravity purity double-purged sugar. This gives the following distribution:

	Sucrose	Gravity Solids
Original Low Grade Massecuite	25.77	45.13
Final Molasses	6.83	18.97
No. 2 Sugar (Original)	18.94	26.16
Double-purged No. 2 Sugar	10.87	12.02
Molasses from double-purging	8.07	14.14

In this system, the "A" massecuite is composed of syrup, double-purged remelt, and "B" sugar from the "B" massecuite. The proportions are computed as follows:

	Sucrose	Gravity Solids
Syrup	86.80	100.00
Double-purged Sugar	10.87	12.02
Base of "A" Massecuite	97.67	112.02

The amount of "B" sugar to be added is determined by trial, based on the following known data: All the commercial sugar (79.97 tons sucrose, and 81.03 tons gravity solids) must be crystallized from the "A" massecuite, and the difference between molasses and massecuite purity is assumed at 16.6 points gravity purity. We then simply add trial amounts of 96.0 purity sugar to the base of the No. 1 massecuite, deduct the sucrose and gravity solids for the commercial sugar, and determine the purities of the massecuite and molasses respectively. After two or three trials, the exact quantity of "B" sugar required is readily determined.

	Sucrose	Gravity Solids
Syrup	86.80	100.00
Double-purged Sugar	10.87	12.02
"B" sugar; (96.0 Purity)	18.24	19.00
"A" Massecuite; (88.48 Purity)	115.91	131.02

The yield of this massecuite is known, so it need not be calculated further. The distribution becomes:

	Sucrose	Gravity Solids
"A" Sugar (98.0 Polarization)	79.97	81.03
"A" Molasses (71.89 Gravity Purity)	35.94	49.99
"A" Massecuite	115.91	131.02

The "A" molasses becomes the "B" massecuite, with the yield:

$$\frac{96.0\ (71.89 - 57.10)}{71.89\ (96.00 - 57.10)} = 50.77\%.$$

The distribution of the "B" massecuite then becomes:

	Sucrose	Gravity Solids
"B" Sugar	18.24	19.00
"B" Molasses	17.70	30.99
"B" Massecuite	35.94	49.99

The low grade massecuite is made up as follows:

	Sucrose	Gravity Solids
"B" Molasses	17.70	30.99
Molasses from Double-purging	8.07	14.14
Low Grade Massecuite	25.77	45.13

SUMMARY

		Per Unit Gravity Solids in Syrup
"A" Massecuite	131.02 Tons	1.31
"B" Massecuite	49.99 "	....
Total No. 1 Massecuite	181.01 "	1.81
No. 2 Massecuite	45.13 "	.45
	226.14 "	2.26

Deterioration of Cane Mill Juices from the Aspect of Acidity Increase*

By W. L. McCleery

For a number of years it has been increasingly evident that during milling operations there is a considerable loss of sucrose from deterioration due to bacterial action. The absence of a direct method of accurately determining sucrose in cane entering the factory has tended to obscure such losses.

Deterioration had been indicated from the comparison of purity differences between first expressed juice and mixed juice in factories operating under the usual conditions, and the lessened difference in these purities when steps were taken to keep the plants in as sanitary a condition as possible. Mr. Elliott, of Paauhau Sugar Plantation Company, and others have done valuable work along these lines. Other tests had indicated that the time consumed in the routine milling cycle was not of itself sufficient to cause appreciable loss through deterioration.

On my inspection visit to the Hawaiian Sugar Company, this year, Mr. Roberts informed me of tests made in 1923 and being continued this year, pertaining to the acidity of the different mill juices. The development of bacteria around the mills results in acid products. In these tests the increase in acidity is used as an index of the amount of bacterial development. In 1923, he had found that the acidity of mill juices in the latter part of the train was as high or even higher than in the crusher juice. This was an unexpected condition as, due to the effect of compound maceration, it would be expected that the acidity would decrease in proportion to the density. Steps were taken to keep down all sour accumulations, etc., as explained later and the results were immediate. On my suggestion the results were expressed as acidity per cent brix. This year, after taking various steps to reduce bacterial action to a minimum, the actual percentage increase of acidity on this basis was found to be very small.

Mr. Roberts has submitted the following report on his work:

During the 1923 crop, several tests were conducted on the milling plant of the Hawaiian Sugar Company to find the cause of the high acidity in the mixed juice. Cane stalks were examined and the juice as expressed by the laboratory mill was so much lower in acidity than that of the mixed juice, that it was evident that the acidity must be increasing in the milling plant.

By analyzing composite samples taken from each mill, from the pans below the mills, from pumps, macerators, juice troughs, tanks and supply pipes, and computing the results, it was evident that the increases in acidity and the subsequent losses due to this action were much larger than had been the prevailing opinion.

The surprising feature, however, was the fact that the increase in acidity from first to last mill was especially marked towards the end of the week, establishing as a practical certainty that the deterioration was mainly due to an increasing unsanitary condition as the week advanced, as the only thorough cleaning was given the mills on Sunday mornings.

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* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

Another feature was the rather large difference of acidity between intake and outflow of the maceration juices, indicating that deterioration was taking place. This was also true in the maceration distributors. (See Table 2.) As soon as these spaces were frequently washed no appreciable increase of acidity was found.

It was expected that the relation of acidity in first mill and mixed juice would be in direct proportion to the dilution applied, but the acidity per 100 cc. was in many cases as high or even higher in the third and fourth mill juices than in the crusher juice.

After data in Table 1 were obtained, a system was started of cleaning and flushing with hot water and lime all spaces through which the juice passed, sometimes three and four times a day, with the immediate result that the percentage of acidity decreased and the clarification improved.

With the beginning of the 1924 crop a routine was started by running hourly, acidity tests on each mill juice and the mixed juice. Acidity figures were inserted in the daily mill reports and each time the increase of acidity was higher than usual, the engineers would take measures to improve the existing conditions. Mr. McCleery on his inspection visit this year advised confining the comparative tests to the mills only, and substituting the figures of *acidity per cent brix,* in place of *acidity per cent dilution.* This was done and all previous work brought to the same standard.

The relatively small increase of acidity in 1924 (Table 3) between Mondays and Saturdays, also between the crusher and last mill, when compared with the data in Table 1 for May, 1923, shows that it is possible for a factory to operate with a comparatively small percentage increase, thereby resulting in considerable saving of undetermined loss around the milling plant.

TABLE I

AVERAGES FOR MAY, 1923

	1st Mill			2nd Mill			3rd Mill			4th Mill		
	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.
Mondays	19.70	.017	.086	9.10	.014	.154	6.24	.010	.160	2.88	.006	.209
Tuesdays	20.31	.018	.089	9.66	.015	.155	6.00	.013	.217	2.77	.010	.361
Wednesdays	20.24	.016	.079	9.50	.017	.179	5.80	.016	.276	2.52	.015	.595
Thursdays	19.60	.015	.077	8.70	.014	.161	5.40	.015	.278	2.20	.016	.727
Fridays	21.00	.017	.076	8.55	.016	.187	5.20	.016	.308	2.05	.015	.732
Saturdays	20.40	.019	.079	8.90	.020	.225	5.10	.020	.392	2.05	.021	1.024
Average	20.21	.017	.084	9.07	.016	.177	5.62	.015	.267	2.61	.0138	.529

TABLE II

MACERATING JUICE FROM SECOND TO FIRST MILL

Average of 30 Tests	Intake			Outflow		
First day	8.37	.018	.215	8.34	.022	.264
Second day	9.05	.021	.233	8.92	.027	.303
Third day	9.02	.023	.230	9.07	.033	.364

TABLE III

AVERAGES CROP 1924

	Average Crop 1924			All Mondays Crop 1924			All Saturdays Crop 1924		
Crusher	19.99	.0096	.048	20.61	.0085	.041	19.70	.0114	.058
First Mill	18.10	.0092	.051	18.57	.0076	.041	18.02	.0112	.062
Second Mill	8.60	.0051	.059	9.00	.0039	.043	8.34	.0061	.073
Third Mill	5.84	.0036	.061	6.10	.0028	.046	5.21	.0040	.076
Fourth Mill	2.13	.0014	.068	2.47	.0012	.049	2.97	.0024	.082

As a result of the work done by Mr. Roberts the writer has made similar acidity tests on his visits to twelve other factories operating under usual conditions. The increase of acidity was found very marked especially in factories with the longer trains. The increase as expressed in percentage, from first expressed juice to third mill juice, and from first to fourth, etc., in factories with longer trains, has been tabulated as given in Table 4:

TABLE IV

ACIDITY INCREASE BETWEEN UNITS EXPRESSED AS PERCENTAGE

Percentage Increase Between Units	1st to 3rd	1st to 4th	1st to 5th	1st to 6th	1st to 7th
Halawa Plantation, Ltd	62	...	...	...	...
Niulii Mill & Plantation	59	...	...	...	...
Union Mill Company	41	...	...	...	...
Olowalu Company*	...	4	...	...	...
Olowalu Company*	...	24	...	...	...
Olowalu Company*	...	29	...	...	...
Olowalu Company	59	86	...	...	...
Olowalu Company	106	140	...	...	...
Olowalu Company	108	122	...	...	...
Olowalu Company	63	91	...	...	...
Olowalu Company	76	87	...	...	...
Kohala Sugar Company	35	122	...	...	...
Kohala Sugar Company	29	85	...	...	...
Waianae Company	94	100	...	...	...
Hawi Mill & Plantation Co., Ltd	34	75	88	...	...
Lihue Plantation Co., Ltd	67	256	300	...	...
Oahu Sugar Co., Ltd., "B"	121	296	435	...	...
Oahu Sugar Co., Ltd., "A"†	77	160	195	...	...
Waialua Agricultural Co., Ltd	56	109	145	...	...
Pioneer Mill Co., Ltd	117	141	237	260	...
Pioneer Mill Co., Ltd	73	105	160	190	...
Ewa Plantation Company	158	285	430	454	525
Hawaiian Sugar Co., May, 1923	218	530	...	...	...
Hawaiian Sugar Co., Crop 1924	19	45	...	...	...

* Tests taken about 20 minutes after starting from a clean mill.

† Test on "A" tandem with unstrained juice pump.

The first three tests for Olowalu Company were taken about twenty minutes after the mill started on three successive mornings. The milling plant at this factory always receives a very thorough cleaning each night. The other Olowalu Company tests were made from 1½ to 2 hours and longer, after the first tests were taken. The increase was fairly constant after 2 hours. The second test at Oahu was on the "A" tandem which has no mill juice strainer, but uses the new Honolulu Iron Works unstrained juice pump. This tandem also has steeper sides to the juice pans under the mills, than has the "B" tandem. The "A" train has the usual type of strainer with drag conveyor and cush-cush elevator.

The type of mill juice strainer in general use is not self-cleaning and sour accumulations gather under the screens. The juice strainers probably account for the largest part of the acidity increase found in the different factories, the balance coming from sour accumulations around the mill beds, cheeks, juice flumes and receiving tanks.

With intensive milling it is probable that acidity increase cannot be entirely eliminated, but the evidence above indicates that when precautions are taken to keep the plants in a sanitary condition the increase can be kept down to a small amount.

Antiseptics are hardly to be recommended, as large quantities would have to be used to become effective. The use of a high pressure hot water hose with a small outlet is, in the writer's opinion, the best means of dislodging all accumulations. The flushing should be done every three hours. If done often, only small amounts of water will be needed and a minimum of juice dilution will result. A steam hose, while effective at points close to the nozzle, would not have enough force to dislodge accumulations under the screen in the juice strainer.

The acidity test is simple and can be readily made in any laboratory with N/2.8 sodium hydroxide and sensitive neutral litmus paper. One hundred cubic centimeters of the juice are transferred to a porcelain dish and the standard alkali run in from a burette, a few tenths of a cc. at a time. After each addition of alkali, stir and test with special neutral litmus paper by making a mark across the width of the paper with the stirring rod. The first trace of blue color denotes the end point. Each cubic centimeter of alkali of the above strength represents .01 per cent acidity in terms of minus CaO. Therefore, a crusher juice titrated as above taking 2.1 cc. of alkali will have an acidity of .021 per cent. With a crusher juice brix of 22.1 the acidity per 100 brix or acidity per cent density would be .095, this being obtained by dividing the per cent acidity by the brix and multiplying by 100. See 1924 Methods of Chemical Control, page 42, "Titration with Litmus."

The saving effected by stopping deterioration around the milling plants is hard to express in definite terms, as the decomposition processes are very complex. If it is assumed that the acidity increase is acetic acid at the direct expense of sucrose, the difference between the 1923 and 1924 conditions at Hawaiian Sugar Company amounts to a saving in sucrose of about 1.75 per cent. Because of lack of sufficient reaction data, this figure may not be very close. From the juice purity aspect more definite figures can be given. A depression in mixed juice purity of 1.0 through deterioration, which is not unreasonable according to

other tests, corresponds to about 1.2 per cent sucrose loss. This in turn amounts to approximately an additional 1.0 per cent lessened recovery in the boiling house, or a total of 2.2 per cent. It is therefore evident that any saving of undetermined loss around the milling plants by preventing deterioration is well worth the effort expended.

Petree Process at Puunene*

By Wm. Lougher

It is rather difficult to write anything on the process without a great deal of repetition, after the able manner in which this subject was reported on at the 1923 meeting of this Association.

The results obtained from the two years' operation of the Petree Process are, we believe, a fairly accurate measure of what can be expected from the process at this mill. Following are figures for the crops of 1922, 1923 and 1924, which are calculated on true sucrose base, and are given to show the comparison with the crop of 1922:

Losses: Per cent sucrose in cane	1922	1923	1924
Bagasse	1.8087	2.9808	3.0510
Filtration	1.3076	0.0868	0.2964
Molasses	7.6425	5.8412	6.2769
Undetermined	0.6747	0.3211	0.2387
Total	11.4335	9.2299	9.8630
Recovery	88.5665	90.7701	90.1370

	1922	1923	1924
Cane polarization	14.78	14.25	14.54
Cane fiber	12.53	11.95	12.00
Cane tons per hour	55.78	52.51	61.25
Dilution per cent normal juice	36.09	38.11	34.06
Extraction	98.19	97.02	96.95
Java ratio	82.35	81.85	81.18

The Petree Process has brought about differences in control that do not make the figures of 1923 and 1924 strictly comparable with those of 1922.

The slightly lower Java ratio since the new control, has brought some criticism, and there may be some basis for this, in that the insoluble portion of the mud passing to the fireroom, doubtless goes out at the same polarization as the bagasse, and this should be added to the bagasse losses. However, as there was a 150-mesh screen used on the Peck strainers during this crop, this amount is small and the correction would not effect the Java ratio to a point warranting

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

comment. It has also been intimated that losses during clarification, or at the mills may be taking place, which would not show with the present method of control. An examination of the following figures, showing the difference between the purities of crusher juice and syrup, points out that no abnormal losses can be occurring at either stage. These are given for the past five years:

Crop	Purity Difference Between Crusher Juice and Syrup
1920	2.01
1921	3.09
1922	2.23
1923	1.63
1924	1.64

The last two years indicate a much better elimination at the clarifiers than at any time previous. This was further shown by the brilliant juice obtained, and a very decided improvement in the quality and handling of the products throughout the boiling house. Turbidity tests are made several times a day on clarified juice, being measured with a Kopke turbidimeter on a portion of the cooled three-hourly composite sample taken for clarified juice analysis. The object is to obtain an average sample of the juices, besides making all tests at a corresponding degree of temperature; the readings were much lower on the cooled, as against those made on hot juices. We have commonly failed to obtain a reading taken on the hot juice at the clarifiers due to insufficient range on the turbidimeter. The clarity of the juice as measured, with a few exceptions, followed fairly closely the P_2O_5 content of the crusher juice.

The process the past year has been subject to the same objections as were found during the first season's operation, i. e., a tendency toward polished mill rollers, and an excessive amount of juice returning to the mills with the mud. Both are detrimental to the extraction, and together with a grinding rate of 16 per cent faster than in 1923, made us unable to obtain the extraction during 1924 that we anticipated when we commenced our campaign.

The effect of the mud at the mills was not felt as keenly this year as it was during 1923. This was borne out by the steady and increased grinding rate maintained throughout the season, although there was practically no difference in the amount of juice returned with the mud to the mills. It again points out the effect obtained from the use of the 150-mesh screen on the Peck strainers, in having removed a still greater quantity of the very fine cush-cush that formerly was passing through the 100-mesh screen in use last year, all of which is returned at the mills, and passes on to the fireroom, thus further relieving the clarifiers of this quantity, and avoiding the chance of dissolving impurities contained by heat and lime. It may be of interest to note the amount of suspended solids removed by 110- and 150-mesh screens from the primary raw juice.

	Per cent on Weight of Juice	
	100-Mesh Screen	150-Mesh Screen
Before strainer	0.479	0.467
After strainer	0.206	0.143
Per cent removed by strainer	56.99	69.8
Difference removed by 150-mesh screen	.....	12.81

I regret that we failed to obtain figures with the 100-mesh screen during 1923. It would be safe to estimate a difference here of 15 to 17 per cent.

The surplus bagasse accumulated this year was approximately 1,600 tons; 1,200 tons of this had to be stored outside of the mill building, the remaining 400 tons were held in the fireroom. The transferring from fireroom to storage pile, and again returning it at the end of grinding, to be used for boiling off, was done with two 18-inch Sturtevant blowers, operated by two 50 h. p. motors, one 1,800 and the other 1,200 r. p. m. in series, using an 18-inch galvanized pipe, over a distance approximately 600 feet from the fireroom to storage enclosure. In addition to this, 614,262 k. w. were supplied for outside power, netting a very substantial credit. During almost the entire crop, bagasse was recklessly consumed at the furnaces to relieve the congestion. The higher rate of grinding doubtless was responsible for a great deal of this accumulation, yet it may be safely stated that the process is responsible for a saving of fifty per cent or more, due to the enormous conservation of heat in juices, cleaner heating surface in boiling apparatus, ease in working of product through the house, gain in higher recovery of sucrose in juice, reduction in labor and materials, most of which means saving of fuel. The cost of manufacture is certainly a very important item in judging the process. This dropped 95 cents per ton of sugar in 1923 and $1.26 in 1924, indicating a saving on our last crop of 63,258 tons, of $79,705. The greater speed of production this year has influenced this figure, but much of the difference is due to saving in labor and material in boiling house, which is directly due to the different method of operation.

The juices are limed after passing through the Peck strainers, the required quantity being controlled at the clarifiers. Primary juice entering the clarifiers is held to a distinct alkalinity to phenolphthalein, while the secondary juice is kept between litmus and phenolphthalein neutrality, giving a combined clarified juice which is alkaline to litmus but slightly acid or neutral to phenolphthalein, this point being found to give best results.

Liquidation of clarifiers has been found most conveniently handled by cutting out one of the units at some convenient time during each week, thus making a cycle of the four units once a month, and is frequently accomplished during a short shutdown for mill repairs, insufficient cane to supply both tandems, or no cane periods. We have found little or no deterioration in the juices occurring during an 18-hour shutdown at the end of each week, and as a guard against any possibility of a change, the temperature is lowered at the heaters and 25 gallons of a 10 Baumé soda solution per clarifier is added continuously over a one hour period before closing down.

Six 30″x18″ Kopke centrifugal separators were installed during this year, and operated the latter two months of the milling season, with the view of eliminating the excessive amount of juice contained in the settlings returned to the mills. The machines are belt driven at 1,225 r. p. m. from 15 h. p. 1,750 r. p. m. motors, and are operated by a crew of three men per shift.

The settlings were limed before passing to the machines, and fed continuously through a nozzle which we designed, to feed at a rate of 15 gallons per minute per machine The feed can be increased or decreased as seen fit, by raising or lowering the pressure head which is regulated by a cone valve to

which is attached a float in the supply tank, having a series of holes drilled in float rod which passes through a pipe guide; adjustments can be made at any time at the top of the supply tank. The separation was effectively done and gave a very clear run-off. The average time per cycle, separating and discharging mud from machines, was approximately ten minutes. The run-off was returned to the secondary cold juice, it being of the same purity as the secondary clarified juice. Besides, the excess lime it contained was corrected, and only a small additional quantity of lime was needed to bring this portion of the juices to the alkalinity required. The mud, being discharged into a mixer, was sufficiently thinned with a small quantity of water that is used in discharging the machines, and its disposal, whether it be returned to the mills or discharged to the sewer, must of course be determined by the per cent polarization it contains. For the period we operated, the average polarization was 5.36 and a moisture of 74.94.

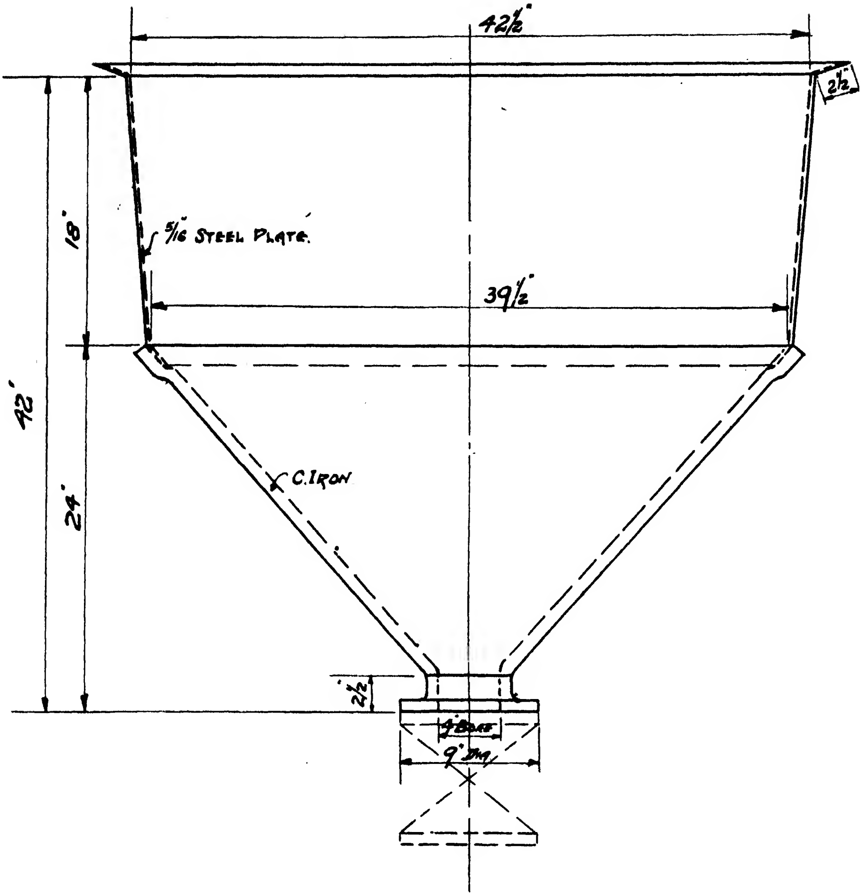
The present installation proved to be only about 60 to 70 per cent of the capacity required to treat the total settlings, which made it impossible to get figures which would be at all comparable. This also prevented us from obtaining the dilution of secondary juice that we had anticipated. Furthermore, had we been able to put the total settlings through the centrifugals it can be safely stated that the polarization of the mud cake would have been reduced by 50 per cent.

The capacity of this station for our 1925 campaign is to be increased by four additional 40-inch machines, which will enable us to treat the total settlings, thereby permitting the necessary dilution at the mills, and the consequent lowering of the brix of the secondary juices, all of which will aid in increasing our recovery.

Best results with the process can only be obtained by keeping the brix of the secondary juice at as low and uniform a point as possible, with a correspondingly lower polarization of the mud. This can be accomplished only by strict observance in maintaining an absolute separation of the juices and the macerating quantities regularly applied at their respective points at the mills; and also by controlling the adjustments on Dorrco pumps on each clarifier to give an even flow of mud at all times corresponding to the quantity and quality of cane ground.

In the event of obtaining a low polarization in the mud, it may be considered preferable to dispose of it to the sewer, discontinuing the practice of its application to the bagasse at the mills. Such a change would not be advisable unless the mill water containing the discarded mud could be distributed over new areas, preventing over-application on that section of the plantation that has been customarily receiving the mill water for irrigation heretofore. However, this point will be decided here when the results from separation of the total settlings are obtained.

The loss of metal or wear of mill rollers with the process is very much less; it appears to be due to the absence of the natural acidity of the juices in the bagasse, which is partially corrected by the lime contained in the settlings. This year we found it necessary to take a light cut with the grooving tool once a month off of all the top rollers, which is somewhat oftener than was our usual practice, but did not require any more than sufficient to remove the polished



Mud cone for Dorr clarifiers.

surface; and it is doubtful even with the somewhat more frequent grooving that we reduced the sizes of the rollers any faster than was done by the action of the acid juices under the former method. However, this, of course, will change in either case, depending on the iron of which they are made and the tonnage ground.

Changes are being made in view of obtaining a better compression of the settlings for the coming season. This consists in lowering Dorrco pumps thirteen and one-half inches, bringing overflow lip of pump to within one and one-half inches above level of juice in the clarifier and in enlarging mud cone at bottom of clarifiers from 18 inches diameter by 6 inches deep to 42½ inches diameter by 42 inches deep. My belief is that this change will aid in further concentrating the settlings and will act as a depositing chamber for the mud as it is scraped off the bottom tray surface. In addition to this, six scraper arms in place of four as originally designed will be used on the lower trays only, which will advance the precipitated bodies to the central cone a little faster than obtained originally.

It was our intention to install the cones last year, but were unable to do so on account of time. The knowledge and description of this arrangement was conveyed to the representatives of the Petree and Dorr Company, at that time and I now understand that this arrangement is being incorporated in their later designs. I was informed by Mr. J. P. Foster recently that the new unit now being installed at the Maui Agricultural Company, Ltd., is equipped with a cone 30 inches in diameter by 20 inches deep. Mr. Foster is presenting his report on the process personally, which will contain an interesting description of piping arrangement for drawing off the mud, replacing the Dorrco pumps. Mr. C. G. Murray, of the Hamakua Mill Company, has expressed his regrets at not being able to contribute, necessary data not being available due to not being through with their harvesting. He no doubt will verbally express his views at the meeting.

My conclusions are that the process as a whole, although it possesses some objectionable features, which can be overcome through experiment and improvement, has given us at Puunene a very substantial return on the money expended, and this is what must finally decide its value to the industry.

Fine Straining of Raw Juice*

By D. G. Conklin

Mechanical difficulties in the fine straining of raw juice have been overcome so that this report will be mainly devoted to the theoretical reasons for fine straining and the subsequent effect of such straining on boiling house work.

The literature of the sugar industry contains numerous references to the desirability of removing suspended matter as far as possible before the operation of defecation. The finely divided matter which is organic is affected by the action of heat and lime, this varying with the state of subdivision of the particles, the extent of liming, and the length of time of exposure to high temperatures. The total amount of impurities liable to go into solution is not great, but its presence is felt throughout the process of manufacture. There is usually an effect found as regards the increase in purity from mixed juice to clarified juice. The H. S. P. A. Experiment Station reports as follows:

It can then be stated that if cush-cush is present when juice is limed and heated, a part of it goes into solution, adding to the impurities in the juice, with the result that the increase in purity secured during clarification is less than it would have been had no cush-cush been present. From a chemical point of view, keeping the mixed juice as free from cush-cush as possible is desirable; indeed, a more thorough screening of the juice than is the usual practice would probably be profitable. Some efforts have been made along this line and the problem does not seem insoluble. In this connection we would note that the fuel value of the recovered cush-cush is a considerable item. Heavy liming of the settlings, from the same point of view, is an objectionable practice, for the greater

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

part of the cush-cush is concentrated in these settlings and conditions are favorable for dissolving further portions of it. While it is true that according to the indications of our experiments, the depression of the purity due to the average amount of cush-cush found in the juice does not appear to be large, a constant effect of this kind results in a loss of considerable magnitude. Record, Vol. XXV, p. 124.

The Station found that the effect of cush-cush elimination was to increase the purity during clarification by 0.2 per cent, and it was found in actual practice that a clarified juice of greater clarity resulted. It was noted that the volume of settlings from strained juice was lessened and that the precipitated impurities settled out more rapidly, particularly in the case of dirty cane. This made for a better capacity at the settling station. It may be possible that the advantage as regards clarification was not due so much to the removal of cush-cush and its soluble components as to the possibility of using more lime for clarification, utilizing the additional settling capacity derived from the removal of much of the suspended matter.

In addition to the advantage of an increase in purity during clarification, there should be an important effect on the quality and quantity of low grade products. This cannot as yet be positively stated, due to obvious difficulty in applying abstruse effects to concrete results. However, the elimination of finely suspended matter is most certainly not deleterious to the working or exhausting of low grade products.

If it is found possible to reduce the cake from strained juice to the same polarization as obtained previously, the loss at this station will be materially reduced. Reports from factories using the fine strainer show that in many instances the polarization of the cake has increased appreciably, although the amount of cake was reduced about 25 per cent. This is, of course, due to the absence of the filter-aid properties of cush-cush. The characteristics of press cake are so variable that it may well be that any alteration in its make-up will have an influence in either direction, beneficial or otherwise. An interesting question is here presented in regard to the amount of sugar actually recovered by excessive washing. It is believed that down to a reasonable exhaustion, washing is justified by the amount of water used in sweetening-off, but after a certain point there is doubt whether the evaporation of the water pays for the extra polarization recovered, and whether there may not be a resolution of impurities from the cake which would more than offset the reduction in polarization. This is a point that is worthy of attention. There are no data available in which the purities of successive washings of the presses are given. It is realized that this would be a difficult problem, principally because of the low density of the last runnings.

Another result of fine straining will be additional fuel, in the form of bagasse, the amount removed varying with the variety of cane being ground, the preparation of the cane before crushing, and the condition of the Messchaert grooves, scrapers, and returner bars, and also on the size of the perforations of the mill strainer. Tests at various places have shown that of the total suspended matter in the raw juice from 15 per cent to 46 per cent is taken out by fine screening. Assuming that the screen removes 30 per cent it is found that with .50 per cent suspended matter on mixed juice, there is removed the equivalent

of .25 per cent bagasse of 40 per cent moisture, on mixed juice. It seems fair to give this removed material the value of bagasse, as it is mainly organic matter, the finest particles, such as silt and soil, being taken out to a much lesser extent.

An advantage from fine straining which is not computable in dollars and cents is the easier cleaning of heating surfaces. With the removal of relatively large quantities of organic matter, there is less left to accumulate on the tubes of heaters and evaporators. The advantage is quite evident particularly where the cane is dirty from adhering soil. In cases where the cane is fed to the mill as in flumed plantations, there will likely not be a compensating advantage.

It is certain that theoretically there should be a real advantage in the fine straining of raw juice, and it may be that with better acquaintance with these new conditions we will find that practice will agree with theory.

Calculations of Savings Due Strainer

Assume a factory handling 100,000 tons of juice per season. At Hawaiian Commercial & Sugar Company, laboratory tests have shown that 0.4 per cent of dry suspended matter is removed from the juice. McBryde gives .15 to .40; and Los Mochis reports 0.3 per cent. Taking 0.3 per cent: 100,000 tons juice at 0.3 per cent = 300 tons dry matter. At 45 per cent moisture, this is equivalent to 545 tons bagasse. With one ton bagasse equal in fuel value to a barrel of oil, at present value of oil ($1.50 per barrel), this is worth $817.00.

Press Cake Losses: Assuming that press cake amounts to 2 per cent on juice and contains 3 per cent polarization, a reduction of 25 per cent weight of cake with same polarization is a saving of 15 tons sucrose. Assume 80 per cent recovery as 96 test sugar: this equals 12 tons of sugar, worth, at $80 per ton, $960.

Molasses: Starting with a syrup of 85 purity and ending with a sugar of 96 polarization, 97 purity, and a final molasses of 38 gravity purity, assuming 12 per cent polarization in juice, a reduction of 1 degree purity in the molasses corresponds to a gain of 48.35 tons 96° sugar, worth at $80 per ton $3868.

Syrup: If besides the decrease in molasses purity of 1 degree, the syrup purity is raised 0.2 per cent, the extra recovery as 96 sugar will be 69 tons, worth $5520.

Extra Expenses: There must be allowance made for interest and depreciation on the apparatus, say at 20 per cent, $500; and replacement of the fine screen, say, three times in the season at $120, or $360. There may be an extra cost for lime; if this amounts to 25 per cent, which is extreme, the additional expense will be about $300 for this material. We then have:

Fuel value bagacillo	$ 817.00	
Press cake savings as sugar	960.00	
Sugar from lower molasses and higher syrup	5,520.00	$7,297.00
Depreciation, etc.	$ 500.00	
New screen	360.00	
Additional lime	300.00	1,160.00
Possible net gain		$6,137.00

These conditions are probably ideal and will not be realized in practice, but there is sufficient margin to warrant the trial in any factory where there is need of improvement in quality of clarification, quality of sugar, or such other operations as cleaning of heating surfaces, to which a value cannot be given with any degree of accuracy.

The following are extracts from reports received from factories which have used the Peck strainer during the past crop.

Mr. Norman King, Chemist at Koloa Sugar Company, writes:

I hesitate to say too much one way or the other until we have had more experience with the Peck fine juice strainer. An average covering a period of five weeks before and five weeks after the installation discloses the following results:

	Before	After
Press cake per cent cane	3.30	2.30
Polarization per cent cake	2.07	3.15
Polarization cake per cent cane	.0683	.0724
Moisture per cent cake	74.76	79.49
Dry non-sucrose per cent cane	.765	.399
Lime, pounds per ton cane	1.67	2.45

Any effect on low grade work was lost in the presence of higher juice purities and the recent installation of a No. 2 massecuite mingler, for the purpose of mixing water into the low grade massecuite prior to drying. It can be said, however, that the quality of work at this station was conspicuously improved.

The McBryde Sugar Company has had a Peck strainer equipped with a 100 mesh screen in operation since January 14, 1924. Contained in a recent statement from this factory are the following:

Immediate Results: After installation the suspended matter dropped to less than 0.1 per cent on mixed juice.

Effect on Press Cake:

	To January 14	After
Cake per cent cane	2.16	1.66
Polarization per cent cake	2.41	2.33
Polarization in cake per cent cane	.053	.039

Increase in Purity: Up to January 14th the increase in purity averaged around 1.1; for seven weeks with the strainer it averaged 1.68.

Evaporators: After the installation of the strainer there was a noticeable improvement in the "cleaning evaporators" item. The scale was light and easily removed.

Fuel Value: The removed bagacillo was equivalent to about 250 tons of bagasse.

Drop in Waste Molasses: The reports show a gravity purity of molasses to and including January 12th of 39.36, and to April 26th of 38.34. There is a drop of one point, part of which should be credited to the strainer.

Mr. B. B. Henderson, of Lihue, writes in part:

On May 1st of this year a Peck strainer was installed in the Lihue factory. No mechanical difficulties were experienced. A weekly cleaning of the screen with hot caustic soda solution was sufficient to keep it functioning properly.

The results of fine screening are not easily arrived at. A new juice was delivered to the boiling house and it is possible that this affected every station and product in the house. These effects might be classified in two ways. First, as results that appear on the factory reports, and second in the working of the products.

Under the first classification the following appear:

	April	May	June	July
Cake per cent cane	2.23	1.75	1.80	1.75
Cake polarization	1.13	3.29	3.49	2.76
Polarization in cake per cent cane	0.025	0.058	0.063	0.048

The results to be recorded under the second classification are far more difficult to arrive at than the first. However, the following is stated: the result of fine screening had no apparent effect on the work at any station that could be observed in the course of manufacture, with the exception of the presses, where at first it was impossible to get a cake. This difficulty was overcome by heavy liming and there was no clogging of the mud lines as sometimes occurred before the removal of cush-cush.

The only results that can be definitely attributed to the removal of cush-cush from the raw juice at Lihue during the 1924 crop are as follows:

1. Double the loss of sugar at the press station.
2. Difficulty at this station overcome by heavy liming.
3. No clogging of pipe lines carrying settlings.

In conclusion, the writer wishes to emphasize that this report is based on the work at one factory covering only a short length of time. Fine screening is to be continued.

At Kahuku, the fine screen was operated during alternate months in an attempt to ascertain, in a practical way, what results could be attributed to the strainer. Unfortunately, our settling tank capacity was under par so that a cycle of less than one hour was not uncommon. This handicap no doubt rendered further comparisons in boiling house work almost useless, since it is obvious that ample settling capacity is essential toward a maximum increase between mixed juice and clarified juice, and, to a similar extent, in the handling of low grade products. It may then be due to the above cause that we report no noticeable difference due to fine screening, either in our factory operations or our laboratory reports, mud presses excepted.

No great difficulty was experienced in getting a good press cake from fine screened juice. Closer supervision at this station was necessary, however, special care being taken in regard to liming, the time in filling and the proper time of washing the presses. Mud press data for the first six months of the 1924 crop are as follows:

	Press Cake per cent Cane	Cake per cent Polarization	Pounds Lime per Ton Cane	Pol. in Mud per cent Cane
Fine screened juice	2.04	3.71	2.23	.076
Ordinary screened juice	2.60	3.04	1.57	.079

Mr. Lougher, Factory Superintendent of the Hawaiian Commercial & Sugar Company, reports:

The value of the Peck strainer is observed in its use for removing the enormous amount of finely divided bagasse, or cush-cush, passing through the mill strainers. The benefits obtained by its removal may be enumerated as follows:

1. Its use in conjunction with the Petree Process is ideal, giving a decreased amount of material to be returned to the mills from the clarifiers, consequently a better extraction and increased fuel.

2. There is a decided increase in the capacity of clarifiers, better clarification, better quality of sugar, lower molasses losses, and lower costs, besides assisting in removing the media that finds its way into the sugar crystals, producing and assisting propagation of bacteria, causing inversion and sugar loss.

3. The extraction of gummy substances from the cush-cush due to the action of heat and lime is avoided; hence, better working products throughout the house. This is especially noticeable in the drying of low grades.

4. The accuracy of control is greater, due to elimination of cush-cush which is otherwise weighed as juice. The figures "bagasse per cent cane" and "tons juice entering boiling house" are more nearly correct.

5. By proper treatment of settlings a press cake can be obtained which will contain only a fraction of the sugar lost at this station when the cush-cush is allowed to enter the boiling house, as only a fraction of the volume of solids is present to be filtered.

6. I will state that all the finely divided suspended matter removed by the Peck strainer will prove a valuable aid to the installation of Kopke separators now being erected, in that the absence of this matter will mean greater capacity by increasing the time of cycle due to the decreased volume of solids to be removed.

I would stress one important advantage of this system of straining the juice. After periods of very rainy weather the cane comes to the factory with large amounts of soil sticking to the cane stalks, adventitious roots, and unburned leaves. This finds its way naturally into the juice and eventually to the presses, and is one of the principal causes of difficulty in filtration. The strainer removes not all but a considerable amount of this unwelcome material from the process, and under such conditions makes for an immediate improvement at the press station.

Another point has been raised as to the possibility of increasing amounts of bagacillo being returned from the mills until more is delivered to the strainer than it can handle; this has never happened at Kahuku. It would appear that the fine material returned to the mill is retained by the bagasse blanket, and a uniform amount regularly dropped into the juice.

In conclusion, the writer would state that during the next season the strainer will be operated off and on during definite periods, so as to obtain more precise information as to the effect on the work of the house.

Plantation Railways and Equipment*

By E. W. Fahlgren

The railway system of a plantation, which uses this means of transportation, is one of its most important units, although in many cases it does not get the same careful consideration and attention as do other units of equal or lesser importance. A fine, big, up-to-date and highly efficient crushing plant and boiling house, with tons upon tons of the finest cane grown, is of little use without adequate means of transporting the cane to the mill and the raw sugar from it.

Railway transportation is unquestionably the most efficient means now in use for transporting heavy loads of any kind. It has numerous advantages, chief of which are reliability, standardization of equipment and component parts, and comparative ease in training men to operate. There are also some disadvantages, the two main ones being the difficulty of surmounting steep grades and negotiating sharp curves.

The work of locating railway lines gives many opportunities for engineering ability of the highest order. The locating engineer should first ascertain the

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amount of money available for construction purposes, the probable amount of traffic, general nature of rolling stock to be used, approximate amount of mileage that will be required, including mill yards, branches, and sidings, and the gauge of track. The gauge of track plays an important part in the locating of lines and should be given considerable thought.

In selecting a track gauge, first consideration should be given to the gauge of any already established commercial railway which would act both as a feeder for incoming supplies and as an outlet for sending raw sugar to the port of shipment. If there is no such railway, then consideration should be given to the gauge of other plantations in the vicinity as inter-connecting railway lines are sometimes very useful. Care should be taken in such cases, however, as the gauge may be one that is too narrow for efficient operation of rolling stock.

The standard gauge of the United States is 56½″ and plantation gauges run from this down to 20″. Plantations in Cuba use the 56½″ gauge, as they operate cane cars of 30 and 40 tons capacity with eight wheels under them, the small 5-ton, 4-wheel car being almost unknown. In the Philippines two gauges only are used, 36″ and 42″; only one Central has a smaller gauge. Brazil uses mostly the meter gauge, 39⅜″. Here, in Hawaii, we have 56½″, 36″, 30″ and 24″. The 36″ gauge predominates on most of the plantations and this gauge has become known as "the standard narrow gauge" among manufactures of narrow gauge equipment.

Carl B. Andrews, in his article on "Transportation" in the *Planters' Record* of 1918, gives the advantages of narrow gauge railways over the standard gauge as follows:

1. Lower original cost, because of the smaller dimensions of rolling stock, requiring narrower cuts and fills and light track, and, because of the possibility of using sharper curves, the ability to fit the line to the terrain closely.

2. Because of the possibility of sharp curves, it is easier to take the track into close quarters near mills, etc.

Among the disadvantages he mentions:

1. The impossibility of changing the gauge to standard after a narrow gauge has been once adopted, without great cost.

2. Delay in obtaining from manufacturers of rolling stock, material, locomotives or cars which differ from the accepted standard.

3. Limitation of carrying capacity because of small locomotives and cars.

The writer agrees with Mr. Andrews in his statement of the advantages of the narrow gauge, but does not agree on all his disadvantages under present manufacturing conditions. The first mentioned disadvantage is, of course, a real one, but it need hardly be considered, for, after a plantation has once adopted a gauge, say of 30″ or 36″, there is hardly any likelihood of their changing it to the standard gauge of 56½″.

The second disadvantage does not apply today, as there are any number of reliable manufacturers of locomotives and cars who specialize in narrow gauge equipment. Some of them carry large stocks of narrow gauge equipment in the various sugar-growing countries. There is a delay in manufacturing some items of narrow gauge equipment, but this applies as well to standard gauge or any

other accepted standard, for no manufacturer keeps locomotives and cars on hand ready to be shipped at a moment's notice, unless it is second-hand equipment.

The third disadvantage still exists but is practically negligible, for none of our local plantations are handicapped by inability to haul their cane to the mill on account of the narrow gauge. If they are handicapped at all, it is through lack of necessary equipment for hauling.

After the above digression the writer will get back to the locating of the railway lines. The locating engineer, having all the foregoing information in his possession, is now in a position to begin his surveys. He should first carefully look over the country surrounding the plantation and ascertain roughly where the railway lines will have to run, ever keeping in mind the necessity of obtaining as low grades as possible even adding a reasonable distance to his line to accomplish this. After doing this, he should start his actual surveys, commencing at the mill site, or from a point where the mill yards will commence. When the line is once permanently located, cross-section work should start so that grading may begin.

Fills should be made wherever possible with a width of 12 feet on top, so that there may be 3 feet clear on each side of track outside of ties. This provides a space for unloading ballast without waste, gives room to walk alongside of a loaded train, and often saves bad wrecks by preventing derailed cars from rolling down an embankment.

Cuts should be laid out to give at least 14 feet in the bottom so that a 2-foot ditch can be made on each side to drain water from the cut.

Drainage is an important factor to consider. Openings provided with ditches leading to them should be put through the grade at all places where water is likely to accumulate and damage the track. If a culvert is to handle this, it should be put in while the grading is being done. Culverts may be of square concrete, concrete pipe or corrugated galvanized iron pipe. A concrete head should be put on to keep the water from washing around the pipe.

Bridges should be of ample length to take care of flood waters. Short spans can be built up very cheaply by using concrete piers and standard I beams. Wide spans, from 20 feet up, should have steel girders or truss construction with concrete piers or abutments. Hard wood may be used in bridge construction, but steel will be cheaper in the end if given proper attention.

Crushed rock makes the best material for ballasting, although sometimes it is possible to obtain river gravel mixed with sand which makes a very good ballasting material.

As curves is one of the chief factors in limiting the tonnage hauled over a railway, it is well to give them careful thought. Due to the many factors involved, it is impossible to give an exact rule for computing the resistance due to curves of any given radius. It is generally considered, however, that the resistance amounts to from .7 of a pound to 1 pound per ton per degree of curvature, the lower figure being used for large capacity cars and the higher figure for smaller capacity cars, as in the latter case there are more wheels and axles per ton of weight than in the former.

The sharpest curve to which two pairs of flanged wheels will adjust themselves, depends upon their distance apart, the diameter of the wheels, and the size and shape of the flanges.

Taking the Master Car Builders standard for flanges and rails and assuming that the gauge is not widened on the curves, a sufficiently accurate formula for all practical purposes is as follows:

$$R \frac{W}{2 \sin a} \text{ in which}$$

R = radius of the sharpest curve that can be passed,
W = wheelbase of car or locomotive,
a = angle the flanged wheels make with the rails.

The minimum radius advisable for plantation use may be taken as about 175 to 210 feet, although in a great many cases a smaller radius has to be used.

The outer rail on all curves should be elevated and the amount of this elevation may be determined from the following formula, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association in 1905:

$$E = .00066DV^2,$$

where E = elevation of outer rail in inches,
D = degree of curve,
V = velocity of train in miles per hour.

Since the elevation required is a function of, and depends upon, the train speed, this speed is the first element to be determined. Ordinarily an elevation of 8″ is not exceeded and speed of trains should be regulated to conform to that elevation.

At the 1919 convention of the American Railway Master Mechanics Association the committee on widening gauge of track at curves recommended as follows:

Curves 8 degrees and under should not have the gauge widened. Gauges should be widened ⅛″ for each two degrees or fraction thereof over 8 degrees to a maximum of ¾″. Gauge, including widening due to wear, should never exceed 1″.

Grade is the other chief factor that controls the tonnage that can be moved by a given power over the railway. The maximum grade must not exceed that up which the power to be used may haul the desired load to be taken up; also the grade must not be so great that the braking power used will be insufficient to stop any downcoming train within a reasonable distance should necessity require.

When a train is hauled up a grade, the resistance due to friction is increased by that due to lifting the train against gravity. The amount of this increased resistance is determined as follows: One mile equals 5,280 feet, and, if the grade be one foot per mile, the pull necessary to lift a ton of 2,000 pounds will be 2000/5280 equals .3788 pounds per ton of 2,000 pounds; the rise in feet per mile must be multiplied by .3788.

If the grade is expressed in feet per hundred or per cent, the resistance in pounds per ton of 2,000 pounds will be 2000/100 equals 20 pounds for each per cent of grade.

To resistance so obtained must be added that due to speed and internal friction in order to find the total resistance in pounds per ton. In the cases of standard railroad cars and the average plantation car using brass or bronze bearings the frictional resistance can be safely figured at 10 pounds per ton of load.

Until just recently too little attention has been paid to the size and weight of rail used for track. Of course, when the majority of our plantations were started, years ago, their locomotives were much smaller and lighter than those of today. Considerable money could have been saved, however, by originally laying heavier iron rails, which were easily and cheaply obtainable in those days.

The average steam locomotive for plantation use today weighs from 15 to 20 tons, and for such locomotives nothing less than 35-pound rail should be used. Forty or forty-five-pound rail would be preferable, as these weights would better bridge over a rotten or broken tie and stand up over soft places without kinking.

In the purchasing of light steel rails there are three kinds to be considered. By light rails is meant those weighing 60 pounds per yard and less. The differences are as follows:

1. "Billet rolled" rails.
2. "Re-rolled" rails.
3. "Re-laying" rails.

"Billet rolled" light steel rails are marketed under no definite specifications regarding the quality of the steel that is used in their manufacture. The result is that this opens up great possibilities for the large primary steel mills (manufacturing "diversified" products) to roll into light section steel rails their accumulation of steel representing off heats or discards, or that spongy portion of the billet which railroad specifications oblige them to eliminate in rolling standard heavy steel rails. It is obvious, therefore, that such mills naturally turn to light steel rails in the effort to utilize such discarded steel that would otherwise have little more than scrap value.

"Re-rolled" rails, it must be understood, are made from standard heavy steel rails and the raw material of the re-rolling mill consists of these heavy section tee rails, ranging in weights from 60 to 136 pounds per yard, which have been taken up from various tracks because their years of service have caused them to wear to such an extent as to make them unusable for further active railroad service in that location, or possibly because they were to be replaced by heavier rail sections due to increasingly heavier traffic. These rails, having been used by the largest railroad interests in this country, were, at the time of their installation, subjected to the most rigid tests covering their chemical and physical qualities.

The rails upon being received by the re-rolling mill are subjected to a preliminary inspection, after which they are broken into such lengths as may be necessary for the manufacture of the new light section rails. This breaking process affords just the opportunity necessary to detect pipes, flaws, or improper molecular construction, as well as other defects which sometimes exist even in a

new heavy rail. Such material, of course, is immediately discarded as unfit for use, for, if an attempt were made to roll it, the defect would become more apparent, resulting in a cobble or scrap rail suitable only for resmelting purposes.

The rails are then charged into a furnace where they are heated to the proper rolling temperature, and from this stage the process of manufacture is identical with that employed by primary rail mills; that is, the heated rail receives the necessary number of passes through the rolling mill to reduce it to a given cross section required for a light rail ranging in weight from 8 pounds to 60 pounds per yard inclusive. After the rail has gone through the finishing pass, it is hot-sawed to the desired length, cooled, straightened, punched for splice bars, and finally passed on to the inspection department where a rigid inspection prevails, with the result that all "A" number one materials receive the classification of "New First Quality" and number two material receives the classification of "New Second Quality," and under these classifications is ready for the market.

This re-heating and re-rolling process overcomes entirely any crystallization which may have occurred in the old rail by reason of its previous service and fully restores it to its original strength and character.

Proof of this lies in the fact that, consistent with the well-known law, the more that steel is re-heated, re-rolled, hammered, or otherwise worked, the finer will be its quality.

Summarizing: we find "Billet Rolled" light steel rails are, for the most part, rolled from offheats, or discards, or from steel which proved inferior for the purpose for which it was intended. Rails rolled under the "Re-rolling" process are manufactured from steel made expressly for rail purposes which has stood the full test required in such use.

"Re-laying" rails are secondhand rails which have been used and taken out of service for any number of reasons. Such rails should never be bought unless an exceptionally favorable price is offered and a rigid inspection made at time of purchasing.

Rails that have been in use for some time should be replaced when the splice bars are being chipped by the wheel flanges, when the side of head is worn as much as $\frac{1}{8}''$ the original width, or when the side of the rail head is worn to the shape of the wheel flange and fillet.

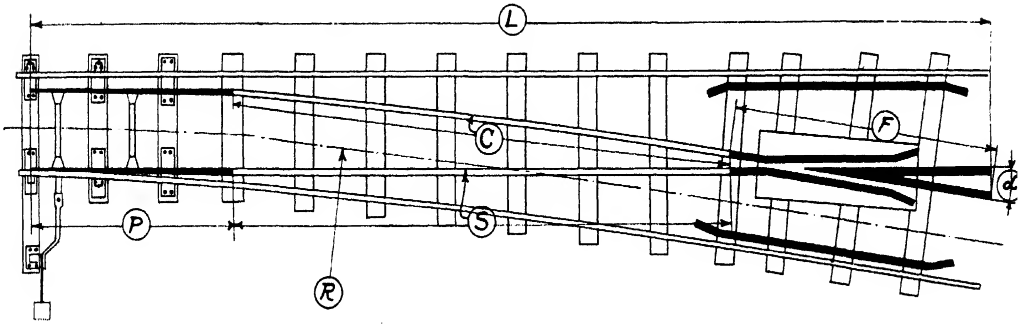
Ties should be at least 5″ by 7″ by 6′, hard wood preferred. Hewn ties are always the best if obtainable, as bearing surface is what is wanted and this is more readily obtained from hewn ties. Ties measuring 6″ by 8″ by 6′ are being generally used as a standard size. No uniform rule can be made for the spacing of ties due to the varying elements that govern this, such as sub-grade, depth of ballast, axle loads, etc., but 24″ center to center of ties has become somewhat of an accepted standard in track laying.

The nail-spike is the American standard for fastening rails to ties and these should be used four to each rail fastening or eight spikes to each tie. Passing trains produce a movement which gradually lifts the spikes out of the tie, but this causes no real danger to traffic provided the spikes are re-driven every so often by the section crew. A test made some years ago by prominent railroad engineers determined that the nail-spike was, in general, more efficient than the

screw-spike. Spikes should be driven straight, as a spike driven with a slant under the rail does not have the holding power of a straight driven spike.

Frogs should not be put in for branches or sidings when laying track, as this necessitates the cutting of rails later when the turnouts are laid. By using one pattern of standard frog all that is necessary afterwards is to open a joint, throw the rail out, and then place the frog. Thus a standard length of lead rail will always fit and it will be interchangeable with any switch on the line. If the joint does not fit the engineer's frog point, open the back joint instead of the front one and then compound the curve to fit the engineer's centers ahead. On sidings it can be moved ahead or back a few feet to suit the joint opened.

The following table will give characteristics of frogs having different numbers:



Frog Number	Frog Angle L	Radius of Curve R Feet	Length L Ft.	Length L Ins.	Length of Points P Ft.	Length of Points P Ins.	Length of Frog F Ft.	Length of Frog F Ins.	Length of Straight Filler Rail S Ft.	Length of Straight Filler Rail S Ins.	Length of Curved Filler Rail C Ft.	Length of Curved Filler Rail C Ins.
3	18° 55′	54	19	8	5	0	3	3	11	5	11	8 3/8
3½	16° 16′	74	22	9	5	0	3	6	14	3	14	6 1/2
4	14° 15′	96	25	11	5	0	3	9	17	2	17	4 1/2
4½	12° 41′	122	29	0	5	0	4	0	20	0	20	2 3/4
5	11° 25′	150	32	2	5	0	4	3	22	11	23	0 3/4
5½	10° 23′	182	35	3	5	0	4	6	25	9	25	10 15/16
5	11° 25′	150	32	2	7	6	4	3	20	5	20	6 3/4
5½	10° 23′	182	35	3	7	6	4	6	23	3	23	4 15/16
6	9° 32′	216	38	6	7	6	5	0	26	0	26	2 15/16
6½	8° 48′	254	41	9	7	6	5	6	28	9	28	11
7	8° 10′	294	45	0	7	6	6	0	31	6	31	7 7/16
7½	7° 38′	338	48	3	7	6	6	6	34	3	34	5
8	7° 09′	384	51	6	7	6	7	0	37	0	37	1 5/16
8	7° 09′	384	51	6	10	0	7	0	34	6	34	7 5/16
8½	6° 44′	434	54	9	10	0	7	6	37	3	37	4 1/2
9	6° 22′	486	58	0	10	0	8	0	40	0	40	2 1/16
9½	6° 02′	542	61	3	10	0	8	6	42	9	42	11 1/8
10	5° 43′	600	64	6	10	0	9	0	45	6	45	6 3/16

Particular attention should be given to the power used on plantation railways. By power is meant anything that moves the cars over the rails, be it animals, motors, or locomotives. Steam locomotives have been, and are yet, the most common source of power for plantation use, although motor-driven locomotives are coming to the fore, and our manufacturers of steam locomotives, for narrow gauge use, are giving considerable attention to this type of locomotive.

The hauling capacity of a locomotive depends primarily upon the weight carried on the driving wheels; hence it is important, in engines designed for heavy service, to utilize for adhesion as large a portion of the total weight as operating conditions will permit. The ideal locomotive, as far as hauling capacity is concerned, would, of course, be one having its entire weight, including that of fuel and water, carried on the driving wheels.

For plantation service it is not safe to assume that there is a standard type locomotive. A locomotive of certain type may give perfect service on one plantation, while on another plantation, where the working conditions are different, it would be an absolute failure. On the large American railroads there are certain types used for switching purposes, others for freight, and still another for passenger, but for plantations, where the service is all switching and freight with varying working conditions, there can be no real standard.

In figuring on a locomotive, do not go by what the other fellow has, but let your conditions of service be known to the locomotive manufacturer who will give you a specification which meets your requirements.

The cane cars as used on plantations are for the most part an entirely different proposition from locomotives and it is possible and advisable to standardize. There are two types of cars used on Hawaiian plantations having the same general construction, but with some deviations according to ideas of best service. Incorporated into these cars are parts or accessories, in some cases of no known standard and, where such conditions exist, the plantation, unless they anticipate their requirements, experiences delays in getting such material. All the manufacturers of narrow gauge railway equipment endeavor to standardize their material and none of them stock anything special. The majority of accessories in the make up of a cane car are standard with all manufacturers and if such is not exactly the case, they at least are interchangeable. When these standard parts are used the plantation does not have the delay in getting parts as they may be purchased from any one of the manufacturers represented.

The use of "side stake" and "side door" cars here is about equally divided. The "side door" car in the opinion of many is better adapted for loading "hapaiko" than the "stake" car, as runners may be rested on the top of the door and the loaders drop their bundle of cane into the car from this runner. The side door also acts as a chute into the carrier when the car is being unloaded. The advantage of this type car is its compactness, as it has no stake pockets or stakes to become loose or get stolen. One disadvantage, while not serious, is ever present, viz., the difficulty in releasing the side doors with the pressure of a load of cane on them. The present type of chain latches holding up the doors is very efficient in its function, but in the cane shed, they are sometimes too efficient in that they do not always easily release the doors. Considerable pound-

ing and hauling at the releasing rings is quite often necessary before they will let go. Several types of door latches have been tried out from time to time, but none of them has been a success. The most successful one is "The Boyum Latch," which is the idea of Mr. E. E. Boyum, and is used by Maui Agricultural Company. This latch consists of a flat steel bar running across the end of the car, bolted to end stakes and having a lug on each end. The chain part of the latch is fastened to the sidedoor with the usual eyebolt on one end, the other end having a link large enough to fit over the lug on cross bar. This link is held on the lug by a two-lipped lever, which is pivoted along the side of the lug. When the lever is in a vertical position, the outside lip holds the link in place on the lug and, when this lever is moved counter clockwise, the inside lip slips under the link and slides it off the lug. No pounding is necessary to release this latch and at the same time it holds the door securely in place.

The stake type car has its adherents, but they all admit the disadvantage of having the stakes lost or stolen. The loss of stakes runs quite high each year. It is surprising how quickly nicely cut stakes can disappear from a car. This loss runs so high in some places that old boiler tubes and rough cut "kiawe" limbs are being used for stakes. It is also quite necessary with the stake car to have stake pockets that firmly hold the stakes in position and that are easily released with the pressure of the cane against them. Several different types of releasing pockets are now being used, all of which seem to be giving a fair degree of satisfaction. Some plantations make side racks for use with this type of car in which case the stake pockets are the solid type and the racks are lifted, more often torn, from the car by means of a hoist in the cane shed.

Neither of the foregoing types of cars, as designed at present, is particularly well adapted for use with the loading machines. The bundles of cane as they are dropped into cars, spring the end walls out and in time these break off. As the loading machines are here to stay, the writer can promise some interesting developments in car design and unloading devices in the near future.

The most economical type of car for hauling cane would be the large 30-ton double truck cars as used in Cuba. Six 5-ton cars will carry no more cane than one 30-ton car, but these six cars not only have 50 per cent more axles and journal boxes, but their maintenance is a serious item in operation costs. The larger car could not be operated on portable track and as most of the Hawaiian cane is transported this way, the large car is out of the question for general use.

The all-steel type of construction in small cane cars has never been popular in Hawaii, and this unpopularity in the main can be laid to two causes: First, because a large portion of our cane fields are on hillsides or high elevations, which means steep grades with the ever-present possibility of wrecks; second, because of the light construction of the steel cars; they could not stand being wrecked and, once they had been wrecked, they were in most cases so bent and twisted out of shape that it was hopeless to try to straighten and salvage them. Today, however, the steel cars are being designed differently so that they will withstand very severe operation usage. End sills are of steel plate, bent U-shape and riveted to top and bottom flanges of all long sills. The entire frame is covered with steel plate which is also securely riveted to all sills which makes a very rigid

construction. This car will some day come into its own, as the maintenance will be so much less in comparison with the wooden construction.

The maintenance and repairs to rolling stock is a very important item in operating costs and in the efficiency of the cars themselves. For this reason a simple form of record should be kept of the repairs made on each car so that the amount of time and money spent may be known. A system should be worked out so that the cars in every train as it comes from the field can be inspected and cars needing any repairs marked so that the trainmen will put them on the repair track. This sounds like a big contract, but one man can walk alongside the train as it moves into the cane shed track and mark the cars needing attention. It is far better to do this than to let a car go until something serious happens to it. The nuts on draft rods should be tightened at the least sign of slackening. Do not let this go until the couplers sag off center, for if they do the couplers themselves will be broken or the threads stripped off the draft rods, allowing the couplers to pull off, which may cause a serious wreck.

Pedestal brace bolts should always be kept tight and brake pins and gear kept adjusted, as brakes are put on cars for a purpose, and a few poorly adjusted brakes on a train can cause no little trouble besides endangering the lives of the brakemen. Stake pockets, hinges, and hinge butts should never be allowed to become loose. Journals should be lubricated at regular intervals to prevent hot boxes. This is one feature of maintenance that quite often receives too little attention. For packing in journal boxes it is well to use a good grade of wool waste, although there are several substitutes for wool waste being used with very satisfactory results. Shredded burlap makes a good packing and is being used by some plantations throughout. In the Philippines where sponges are cheap and plentiful they are used with a fair degree of success. Coconut fibre is also being used and from the latest reports is proving a very good substitute.

In packing journal boxes, the waste or whatever is used should be submerged in oil for about 48 hours, endeavoring to keep temperature of oil approximately 30 degrees C. during the entire time of soaking. The surplus oil is then drained off, allowing sufficient to remain to approximately equal 5 pints of oil per pound of dry waste or substitute. The packing placed in a journal box first should be in the form of a twisted roll, pressed out moderately dry and packed tightly around the back end of the box, for the purpose not only of retaining the oil, but also better to exclude dust and dirt.

After this is done proceed to pack the box with loosely formed packing sufficiently firm under the journal to avoid settling away, which is caused by shocks when the car is in motion. Pack it more lightly on each side of the journal to avoid the wiping effect, produced when waste is pressed too tightly between the journal and the side of the box. Height of packing should not extend above center line of journal and not beyond inside of collar.

The portion of packing placed between end of journal and front end of box, being the last put in, should have no thread connection with the packing under or on side of journal, and should not extend more than one-half inch above lower edge of collar. This packing affords no means of lubrication to the jour-

nal, but prevents packing on sides and under journal from working forward out of normal position for satisfactory service.

The most important part of the work for successful lubrication is intelligent attention to the packing in boxes on equipment in service and briefly consists of lightly loosening up the packing on each side of journal to avoid the hardened and glazed condition, which is caused by the packing remaining too long in direct contact with journal. This work can be effectively accomplished by the use of a good tool which should have a V-shaped end. No attempt should be made to raise the whole body of packing in the box, as is sometimes practiced by means of tools with square or blunt ends.

Attention should be given to equipment at frequent intervals or at such time as the condition of packing will indicate it to be necessary. Oil should not be added to journal boxes until the condition of packing is ascertained to require it, avoiding the excess use of oil as evidenced by the accumulation on the wheels and outside of boxes. When using the oil can, oil should be placed on side of journal, and when saturated packing is used as a lubricant it should be placed in contact with journal. Cars in shops for repairs should have packing removed, repicked, and replaced. This work need not be done at closer intervals than twelve months, the object being to maintain an elastic condition of packing.

Brasses should not be transferred from one journal box to another, and before applying suitable sized brasses, the journal and the surface of brass should be oiled. A new close-fitting dust guard should be applied in all cases when renewing wheels and when practicable after a hot journal has occurred.

For the lubrication of journals by trainmen, saturated packing only should be furnished; all packing removed should be returned to points where it is prepared for distribution.

The accessory business for railway equipment has become almost like the automobile accessory business in the number of different ideas for parts, but, unlike the automobile business, the ideas offered are not so freakish in design. Car couplers show perhaps the most numerous of varied designs and ideas. The spring type coupler offers the best field for improvements, as it is generally conceded that this type of coupler is the best, in that it is the easiest on cars on account of absorbing all buffing and pulling strains. The majority of these types of couplers now have the links and pins fastened in the head, preventing these two parts from getting in with the cane and going through the rolls.

Wheels, perhaps, next to couplers, show a wide variety of designs. In Hawaii the spoke type wheel has always been the most popular, due, no doubt, to the ease of braking cars by throwing a stake between the spokes. Cast steel makes the best material for plantation wheels, although one or two or our plantations are using and getting good results from solid cast iron wheels having well-chilled treads. A properly designed steel plate wheel can be made lighter in weight and with less chance of the treads giving away than a spoke wheel. This is due to their being supported around the entire circumference. Spoke wheels are today being designed with enough weight so that there is little likelihood of their treads giving away between the spokes. Most of the damage being done to wheels today is from flat spots on their treads caused by the locking of brakes so that

the wheels slide along the rails. Some brakemen have the idea that brakes are not holding unless the wheels are sliding, which idea is not only erroneous, but disastrous. Wheels are worn flat in spots and, in case of wet rails, there is the possibility of cars running away, which almost invariably results in wrecks. Wheels should have good wide treads and full, well-rounded flanges; the latter to prevent catching in frog and switch points.

Cast steel is coming more and more into use as material for car parts, and before long all such castings will be made of this material. The most distinct change to cast steel, for plantation use, during the last two years, has been the making of brake shoes from steel. We have had brake shoes with steel backs and with steel inserts, but never a shoe made entirely of steel. Brake shoes have always been made of cast iron and will probably continue to be so made for general use. Iron shoes are easier on wheels, as the shoe wears instead of the wheel. The disadvantage is, that the lugs for holding shoe to head are easily broken off. Steel shoes have the advantage of permanent lugs, but they are hard on wheels. In spite of this, however, they are being used with great success on several plantations which have very severe grades, and here it is claimed that the steel shoe holds better than the iron one, even though the wheels are worn, and that fewer wrecks have occurred on that account.

A Method of Handling Cane Tassels for Breeding Work

By J. A. Verret, in collaboration with Y. Kutsunai, U. K. Das, Raymond Conant and Twigg Smith

During the present breeding season we developed a system of handling cane tassels for breeding which gives promise of being of tremendous help in the work of crossing and selfing cane varieties.

None of the methods used heretofore were wholly satisfactory. Emasculation is, of course, out of the question. The bagging method, the method mainly used in this work when accurate results were desired, is not satisfactory for several reasons. If cloth heavy enough to prevent the entrance of foreign pollen is used the shading seems to weaken the tassel greatly and poor or no germinations result. If the cloth is too light one has no assurance that other pollen has been kept out, so the object of the work is defeated.

On account of these unsatisfactory results the majority of cane breeders working on a large scale have resorted to the so-called "tying-on-of-tassels."

All breeders are familiar with the details of this method and we shall not describe it. It involves a great deal of work requiring the continuous change of tassels and, of course, no great protection against foreign pollen. Under the best conditions the cut tassels soon die. So in order to have good fresh pollen on the stigmas in their most receptive stage some breeders change these tassels in the night, generally from 2:00 to 4:00 a. m.

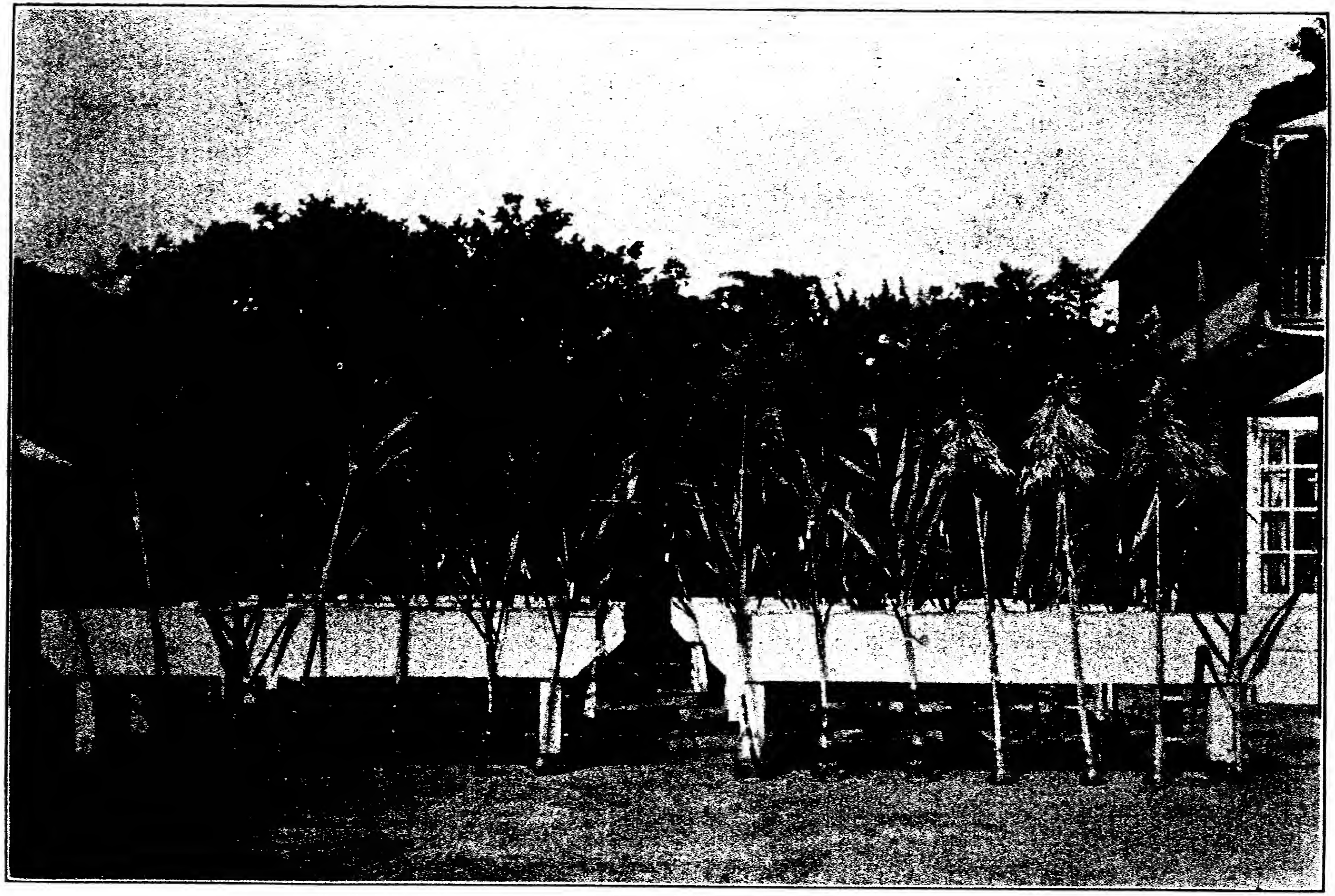


Fig. 1. General view of tests with the various solutions being tried. Such a layout can also be used for selfing or crossing if properly protected from foreign pollen.

Our method consists of the use of a certain solution which keeps the cut tassels fresh and developing normally for a long period of time. The method is not by any means perfected yet, as we have but recently started its use on cane tassels. But we feel that by making it public now other breeders can do work with it and in that way hasten its perfection.

After conducting a large number of experiments (one hundred or more) with all kinds of preservatives and other solutions we found that by placing the cut end of a cane stalk, with or without a tassel, in a solution of sulphurous acid (SO_2), 1 part in 2,000, it will keep alive, in apparently normal condition, for several weeks. After being once placed in the solution no further attention need be paid to the tassel except to see that it does not grow beyond reach of the tassel to be pollinated.

Microscopical examination of pollen from tassels cut from one week to ten days shows no differences from pollen from fresh tassels. We have obtained germinations from pollen taken from a tassel cut five days before, as shown in the following record by C. C. Barnum, of the Pathology department:

TASSEL CUT NOVEMBER 7, 1924

On November 11—pollen collected 12:00 Noon—germinated
On November 12—pollen collected 1:00 P. M.—germinated
On November 12—pollen collected 4:00 P. M.—germinated
On November 13—pollen collected 8:00 A. M.—germinated

TASSEL CUT NOVEMBER 17, 1924

On November 20—pollen collected 9:00 A. M.—germinated
On November 20—pollen collected 4:00 P. M.—germinated

It is very difficult to get cane pollen to germinate under any conditions so the getting of these germinations of pollen from cut tassels shows the pollen to be good.

Showing that the cut tassels kept in the sulphurous acid solution develop normally we have the following:

On October 21, three tassels were cut at the Manoa substation (these were the first tassels of the season) brought to the main office and placed in the solution at once. When cut, the tassels had not fully emerged and no stigmas or pollen sacks were out. These tassels were of the same variety and were kept isolated in a greenhouse, On November 6, the tassels had matured and the fuzz was planted. On November 12, we obtained germinations.

These results offer great possibilities in crossing and selfing work. If tassels so handled give good germinations it will be a simple matter to so isolate them as to be sure no other pollen has contaminated them.

In our work with the sulphurous acid solution we have found there are several things to be especially guarded against. One is to be sure that the sulphurous acid solution does not contain sulphuric acid. This may be the case with old solutions which have been exposed to the light. If any sulphuric acid be present the work will result in failure.

The next precaution to take is to have a solution of the proper strength. The solution should be strong enough to prevent turbidity but not be so strong as to burn the leaves. In other words, use the weakest solution that will prevent turbidity. We find a 1 to 2,000 freshly prepared solution to be satisfactory. It is possible that it can be somewhat weaker than this.

We find it more satisfactory to prepare our solutions ourselves with SO_2 gas. We prepare a 5 per cent SO_2 solution by slowly bubbling the gas through water. This is diluted as we want it, 1 cc. to 100 with water. Fresh stock solutions are made every week or so.

Another precaution for successful work is to place the tassel in the solution at once. When getting tassels some distance from headquarters, the cut ends are put in water immediately after cutting. On arrival where they are to be used, one joint is cut off under water and then the tassel goes to the solution at once, where it must remain continuously. Unless this is done failure generally results.

We leave from 2 to 4 feet of cane stalk with each tassel. The sugar in the stalk apparently is used for food by the plant in the solution, as at the end of two or three weeks or in some cases longer, there is no sugar left in the stalks.

The methods in use here previously and the various steps that led to the development of the new method are given briefly in the following paragraphs:

Heretofore in our work here the pollen-bearing tassels of sugar cane for artificial pollination have been obtained some distances away, brought to the station grounds, and treated somewhat as follows:

The lowest joint was cut away under water. The tassels were transferred to a container with clean water, taken to the female tassels or left leaning on a table so that the pollen grains could be utilized. The water in which the tassels were left standing was changed once or twice a day.

The changing of the water was found rather difficult in some of the high cages, and sometimes the waste water was poured accidentally on important tassels. To obviate this difficulty experiments were started to find a method suitable for keeping cut tassels alive and growing for say a week to ten days without changing water.

The drying of the cut tassels was thought to be due to clogging up of tubes through which water was taken up or by toxic substances in the water. This clogging could be brought about by some organisms in the water or in the cane stalks, by the suspended matter in the water, or by some decomposing material of the sugar cane itself.

From past experience, it was suspected that the growth of some sort of organisms in the water was responsible for the early death of cut sugar cane, and the source of these organisms was thought to be the surface of the cane. Hence, the first part of the experiment was to disinfect the cut ends. It was soon found that a dilute disinfecting solution was better than the treatment of the cut ends.

The results so far obtained show two methods of value:

(1) Lowest joint is cut away under water each day and the water in which the cane is standing is kept clean and fresh.

(2) Lowest joint is cut away under water, and the cane is transferred to a dilute solution of sulphurous acid, 1 part SO_2 gas in 2,000 parts tap water. The

Fig. 2. Stalk being placed in the sulphurous acid solution. Note the partly emerged tassel.

solution is changed whenever turbidity is noted. As a general rule we have no turbidity if the sulphurous acid solution is properly made. When it is necessary to change a turbid solution one may as well change the tassel also, for if it has once commenced to wilt it will not recover.

The following notes by Mr. Das give a few typical tests made and show the progress of the work to the present time.

In this work Mr. Das has shown resourcefulness and initiative and deserves great credit for the results obtained:

The following gives steps taken in developing the sulphurous acid solution method of keeping cane tassels:

The tassels are cut with 2 to 4 feet of cane stalk (joints) on them.

(1) The cut cane is put in tap water, changed every day.

(2) The cut ends are immersed for about one minute in acid and then put in water.

(3) The cut ends are immersed for one minute in alkali and then put in water.

(4) The cut cane is put in a standard nutrient solution.

The canes all began to wilt and die in two or three days and slime was detected. The next step was to have the slime examined by the Pathology department.* It was found to contain bacteria, protozoa and fungi. Henceforth, our efforts were directed to controlling the growth of slime or keeping it in check. The first disinfectant used was mercuric chloride (1 in 20,000). This gave a better result and confirmed our belief that slime was an important factor. In another test the cut cane was put in tap water which was changed every day, and each day the bottom joint was cut off, thus exposing a new surface to the clean water. The sticks did very well and we were able to keep them fresh two or three weeks and even longer. We later found that it was necessary to always cut at least one joint every day. It is necessary to cut off a node each time.

Mercuric chloride (1 in 20,000) did not, however, come up to our full expectations. We thought it was too strong and we thereafter used more dilute solutions down to 1 in 100,000. There was no growth of slime, but the cane sticks never did very well, or as well as the sticks in water which had one joint cut every day. $HgCl_2$ together with sugar solutions of various strengths and standard nutrient solution was later on tried, but no encouraging result was obtained. Some canes were first sterilized for different periods in $HgCl_2$ and then put in water changed every day, but with the same result.

We then tried cane sugar solution of various strengths, but in all cases the canes began to die in two or three days.

We also used lime water, soil solution and many inorganic salts such as ammonium chloride, magnesium chloride and lead chloride. We tried camphor, ether, chloroform and alcohol in water, but with no success. We then concentrated our attention to finding some mild disinfectant that would not have the killing power of mercuric chloride, but which would be as effective in keeping off the growth of organisms in water. We have tried the following:

* The Pathology department has been of great help in this work. At the present time Mr. Barnum is devoting all of his time to a study of pollens and related problems.

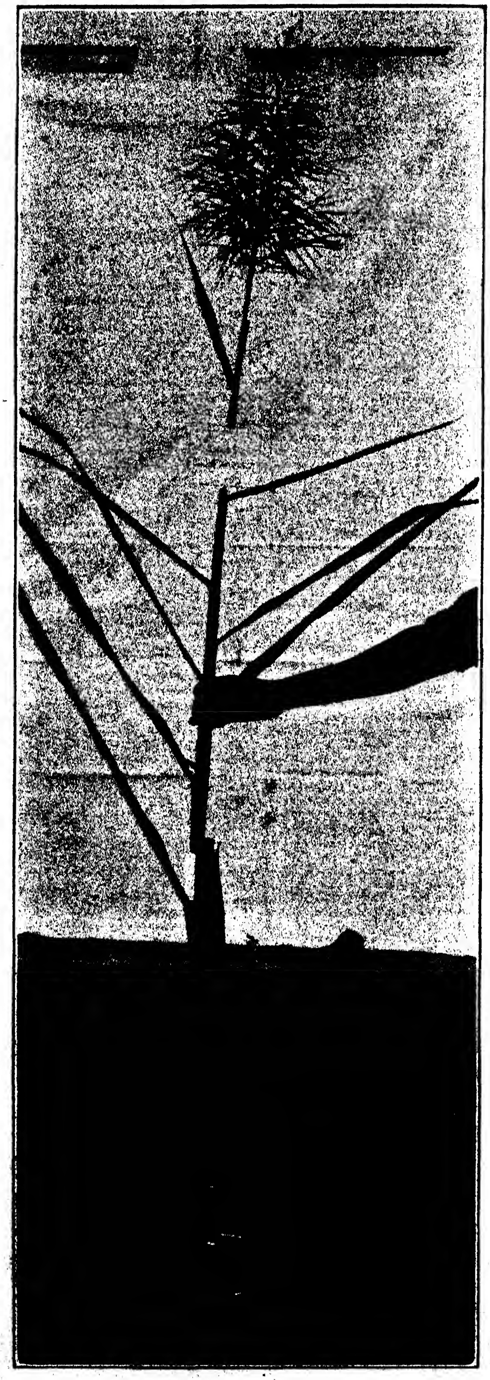


Fig. 3. This stalk has been in the sulphurous acid solution one week. Flowers are still opening and are giving good pollen.

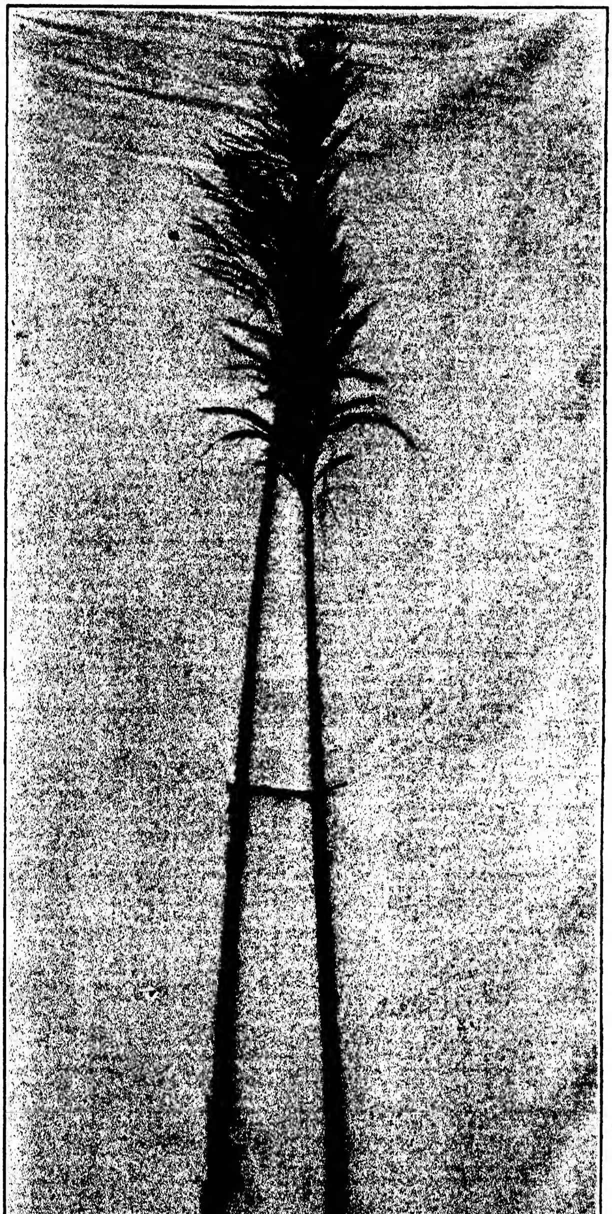


Fig. 4. Method used in obtaining crosses by means of the sulphurous acid method. Tassels of the varieties to be crossed are placed in the solution and kept in a sunlit pollen-proof room. In the early morning the tassels are shaken to scatter the pollen. When mature, all tassels are planted.

(1) Potassium permanganate—1 gm. in 1,000 cc. of water.
(2) Aspirin—20 grains in 1,000 cc. of water.
The cane did fairly well for about six days, but soon after the leaves began to die.
(3) Formalin (40 per cent commercial product) 5 cc. in 1,000 cc.
It was too strong; leaves appeared scorched.
(4) Boric acid—.1 gm. in 1,000 cc. of water,
.5 gm. in 1,000 cc. of water.
(5) Hydrogen peroxide (commercial product)
250 cc. in 1,000 cc.
143 cc. in 1,000 cc.
With (3), (4) and (5) the leaves became dry and brittle in one day.
(6) Sodium sulphite—2 gms. in 1,000 cc.
(7) Sulphurous acid (H_2SO_3) various strengths.
Sulphurous acid has proved successful, though we cannot say it is perfect as yet. We shall give our trials with sulphurous acid in some detail.

The first experiment with sulphurous acid was started on September 15. The strength used was 1 cc. of the commercial product (original analysis 8.3 per cent SO_2) to 100 cc. of water. In a day or two it was noticed that the leaves not only kept fresh but there was a marked growth of stalk. This growth continued as long as the stick was alive, though during the later stages the rate of growth fell off.

The first stick was alive about a week when, through some accidental circumstances, the experiment was lost. However, it gave us very good indications and we tried another batch of new canes. All these stood the test remarkably well, and in all cases the cane was alive for more than two weeks. In one case the stick was alive for about one month and the growth during the period was nearly one and one-half feet. During all these days the solution was not changed, nor was any part of the stalk cut off. As the solution was taken up by the stalks new solution was added to make up. Our attempt was now to find the optimum strength of the solution in which the cane will do its best. We now tried the same acid diluted as follows:

.5 cc. to 100
1 cc. to 100
1.5 cc. to 100
2 cc. to 100

It was found that while the cane did pretty well in all these solutions, the solutions of higher strengths (1.5 cc. to 2 cc. to 100) had some strong effect on the leaves. The solution .5 cc. to 100 turned turbid at the end of 8 days and the stick died soon after. So it was concluded that 1 cc. of the acid to 100 water was the best strength. We then began to apply our experimental results on a big scale and under regular field conditions. Here we were faced with one minor difficulty. The original stalk of H_2SO_3 being finished, we had to use acid freshly prepared in our laboratories. We found that 1 to 100 of an 8 per cent H_2SO_3 was too strong for the leaves. We then worked down to 1 to 100 of a 5 per cent acid freshly prepared. This time we got the same results as in our previous experiments. The sulphurous acid first used had probably weakened on standing. This probably explained the incongruity in the experimental results. How-

ever, we have now given this 1 to 100 of 5 per cent acid a fair trial and are getting fine results. We have been able to keep tassels alive in this solution for two weeks and even more. We have obtained good pollen all the time and some actual germination of seedlings.

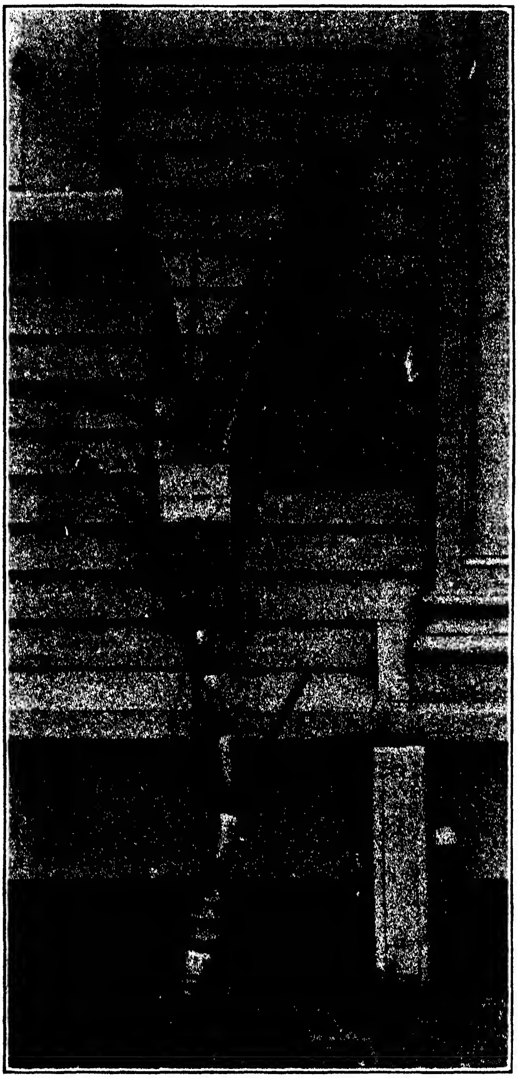


Fig. 5. This stalk has been in the sulphurous acid solution for over a month. The tassel matured, was planted and germinations obtained. Note the sprouted eyes. All of this growth has occurred since placing the stalk in the solution. Selfs may also be obtained in this way.

We still feel that some more improvements could be made, even on this, and we have been trying it in many other ways. We have also been trying other organic acids and salts and some other disinfectants.* But one point especially associated

* Since writing the above we have started a test with Dakin's Solution with very encouraging indications.

with this H_2SO_3 is its power of stimulating growth. In this connection, we may mention one interesting experiment we made with ice. The cane put in ice looked fresh, but as soon as ice was withdrawn it died. During these three or four days there was no growth at all.

The Propagation of Seedling Canes*

Notes on Collection of Tassels and Nursery Technic

By W. P. ALEXANDER

The Committee on Varieties feels that every effort should be made to improve the technic employed in the propagation of seedling canes. With this aim in view they believe that as a starting point all information which is available should be recorded sooner or later, and that such an exchange of data will increase progress.

The subject is demanding attention under the following heads:

(1) Botanical Studies of Cane Flowers.
(2) Methods of Securing Natural Crosses in the Field.
(3) Methods of Securing Artificial Crosses in Field.
(4) Methods of Caging Flowers Either for Selfs or Crosses.
(5) Nursery Technic.
(6) Selection of New Seedlings:
  a. Preliminary eliminations.
  b. Choice and development of new commercial varieties.

Since only a long treatise could completely cover the project, this report will attempt only to treat of two of the above points, Nos. 2 and 4, namely, the securing of natural field crosses without artificial means, and the nursery technic involved in growing the seed. It is this work that can be undertaken successfully by the individual plantation with little financial outlay and the least amount of experience. The results may not be secured along strictly scientific lines of a plant breeder. Nevertheless in spite of this haphazard manner of securing crosses, the results justify such "commercial" raising of new varieties. H 109 in Hawaii, D 625 in British Guiana, probably E. K. 28 in Java, and others, are the products of this process.

The more delicate work in obtaining artificial crosses in cages or otherwise should be encouraged by all and receive the consideration of specialists at the Experiment Station until a more complete system than we have at present has been perfected.

The mode of procedure in collecting tassels and the planting and care of seedlings in the nursery will vary according to different conditions, and it is not

* **Presented at the Third Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.**

the purpose of this report to lay down rules to be followed. "Experience is the best teacher." The findings and the practices adopted by some of the cane breeders working in Hawaii have been brought together and are presented in detail. There is some repetition of ideas within the different quotations and the methods have been gone into rather minutely, for the report is written mainly for the use of those who are intensively engaged in the project.

Some interesting developments of the 1924 season are described and may be briefly mentioned:

(1) Mud press (decomposed) as a media on which to germinate fuzz was used by W. P. Naquin at Honokaa. (See page 102.)

(2) An incubator for germinating fuzz during unfavorable weather was operated by W. C. Jennings at Hawi. (See page 99.)

(3) Green algae and fungi in the original seed beds were controlled by Bordeaux dust and by using a surface soil having little or no organic matter. (See pages 102 and 108.)

The writer is indebted to Messrs. W. C. Jennings, Y. Kutsunai, W. P. Naquin and C. F. Poole for their cooperation in the preparation of this report. Their help made possible a fairly comprehensive summary of the *present* status of our information concerning the collection of tassels in the open field and the nursery technic.

Collection of Tassels

To provide the proper seed material, the collection of tassels when secured in the open field requires careful planning and strict attention to certain fundamentals.

First, the cane breeder must obtain his tassels with a definite purpose in mind as to the new variety wanted. It is profitless to indiscriminately secure tassels without a reason. For example, at Ewa, we keep two points in mind, namely, resistance to eye spot leaf disease and an early maturing of the cane. Mr. Jennings, in Kohala, says: "In our seedling work in Kohala our first aim is to breed canes that will be improvements on D 1135 and Tip canes, the present standard varieties of the district, and we consider that the first logical step in this direction would be the crossing of these varieties. In these crosses we expect to find combinations of the best characters of both varieties, and with these combinations of characters we would expect to develop mostly mauka varieties. In our work on the development of lower-land canes we have attempted to cross D 1135 and the Tips with Badila, Striped Mexican and H 109." The choice of the right parents is most important and the writer can frankly state that it is his experience and that of others that the promiscuous planting of seed from many inferior non-commercial canes has caused a loss of time and energy which could have been devoted to more profitable crosses.

Certain botanical knowledge should be secured about the inflorescences of each variety of cane. It is a great aid to the efficient collection of the tassels. Armed with such information no time will be wasted securing tassels from varieties in which the female part of flower (ovule) is not normally developed. One

should know also what varieties produce little or no pollen. More data is needed on this subject in the Hawaiian Islands. In India and Java and Cuba* a great deal of work has been done so that cane breeding is progressing without "waste motion." Here are some "observations" that have been made in Hawaii: H 109, Lahaina and Tip canes can be counted on as splendid female parents. Their male function is often in doubt. D 1135 is able to serve well as either parent. H 146 has most virile pollen. Badila has normal reproducing organs when it does tassel, which is seldom. Yellow Caledonia is sterile (a mule). Fertile seed is more easily obtained in any case when different varieties are in proximity, i. e., when crosses are actually secured.

A preliminary survey of the possible parents at hand and the location of their relative position in the field so as to serve as crosses is the common plan of procedure by Jennings, Kutsunai, Poole and the writer.

The tassels selected for the seed material will be at the leeward side of the hoped-for pollinating variety. Under ordinary conditions the two varieties desired to be crossed seldom seem to have mature flowers at the same time in the same locality. As pointed out by the writer in a report on tasseling, a year ago, there is a large field for investigation as to the phenomena of tasseling. If as claimed in India† we could control the time of tasseling, crossing of different varieties would be more certain.

Inspection is made as often as possible to watch the progress of tasseling and be ready to cut the tassel when ripe.

Theoretically, the collection of the fertile seed should not be difficult, in practice, the reverse holds true. Only through tireless energy and by many careful observations will one succeed in obtaining seed that will germinate well. Then in spite of the best laid plans, the weather conditions may be unfavorable. It appears that during the period of flowering prime conditions are, dry weather and little wind. Normal transferrence of the pollen to stigma will not take place if there is high wind which dries up the stigmas or blows away pollen grain before they mature and wet weather which washes off the pollen grains, or they may burst prematurely after they absorb moisture. Also after pollination has taken place, the plant seems to require good growing conditions so that the seed may reach full development. So it is that Kutsunai looks for "a vigorous cane which is always chosen as the one from which to take tassels. Tassels from a long crop are preferred to those from a short crop, also a field with heavy tasseling is thought to give better germination than a sparsely tasseled field. As far as possible, the tassels in more or less protected places are cut.

"Tassels on weak stalks are smaller than on well developed sticks. Many tassels emerge merely to dry, showing that the stalks below have no reserve energy to ripen the seeds. This condition is very closely correlated with young

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*Venkatraman, T. S., Agricultural Journal of India, Vol. XVII, Part 2.
Handbook Sugar Cane Culture in Java—Chap. VII.
Calvino, E. M., Studies in Anatomy and Physiology of Sugar Cane in Cuba.

† Venkatraman, T. S., Agricultural Journal of India, Special Indian Science Congress Number, 1917.

cane, weak growth, and late tasseling. Sometimes heavy wind brings on premature drying of the tassels. Cane along ditches and leeward edges is usually well developed and are satisfactory for the source of tassels."

The uncertainty of weather conditions is a factor everywhere, to quote Jennings, "My working plan each day during the early part of the season is based upon the assumption that each particular day may be the last opportunity for collecting tassels before heavy wind or rain damages the tassel crop for the season." The tassel may take two weeks to entirely emerge and the flowers on the tassel bloom gradually from the top down, and it may take another two weeks for the tassel to complete its entire florescence. In order to get some seed at least before the weather turns unfavorable at Ewa picking tassels is started when the tops only are mature. However, collection of tassels in earnest proceeds when the whole tassel has flowered. At this time the fuzz will shake off easily and the stem of the tassel has started to wither and turns yellow. In Java the flowers are cut when the last small leaf, the little flag, begins to dry. A much larger collection of tassels must be made from each location than may actually be wanted for planting, and these will be stored until germination tests have proven their value. If one does not have a surplus on hand he is likely to find himself without enough seed if the season prevents further tassel collection or if there are adverse conditions resulting in mortality in the nursery.

Experience of all those doing seedling work has shown that it is the early tassels, even though only the top is ripe, that usually give the best results, although Jennings reports, "occasionally, under Kohala weather conditions, earlier maturing tassels may fail to set seed, while late tassels may give good results."

If there was a sure test of the fertility of the seed that could be made in the field or before planting, time and labor might be saved. Jennings' experience of having one lot of fuzz in six providing fertile seed, is a good ratio even under better weather conditions. The only practical means of testing seems to be to plant a representative sample, and the resultant germination will decide whether the balance of the seed is to be used or discarded. Kutsunai describes some of his methods for the examination of seed in the fuzz and also viable pollen:

Usually a few early tassels are cut and examined for seeds. The fuzz is scraped, rolled forcibly between the hands, and all solid particles are examined with a magnifier of 10 to 20 diameters. Another and a better method is to grind the fuzz in a meat chopper with the knife set about 1/8 of an inch open, the ground fuzz is stirred in water, and all the particles that have sunk down to the bottom are examined with a lense of 10 to 20 power. The seeds are often broken but can be easily recognized. These two methods are very quick but more or less crude.

Iodine stains pollen which appears to be good and normal. But the iodine does not differentiate live pollen from dead pollen. The methods look good for obtaining percentage of viable pollen in the flowers. For want of a good method for germinating pollen, the results of iodine tests could not be checked with viability of pollen.

Bare seeds placed on blotting paper the edges of which have been folded into a well of water germinate well. When the fuzz is tested, the seed bed of soil is thought to be quite satisfactory.

Usually the whole tassel is cut without the stem. Sometimes, however, the collector may only take the top portion. Again, one may prefer to leave all the stem and even several joints of the stalk.

TREATMENT OF TASSELS

The tassels are bagged in the field and labeled for identification of parents, etc. Kutsunai and Jennings have used muslin bags; Alexander and Poole find paper bags are cheaper and answer the purpose. The treatment before planting the fuzz has not been standardized, and perhaps more care in drying tassels should be exercised as the excellent results secured by Jennings would indicate. His methods are described in full:

> The greatest difficulty in the care of tassels after cutting is the prevention of mildewing before planting. If the fuzz is not well cared for the mildewing will become evident immediately after planting, even though not noticeable in the muslin bags. The bulk of the tassels are cut when only the tips or upper halves have ripened, which makes curing difficult, especially in cloudy, rainy weather.
>
> The tassels when brought in from the field are hung up in bundles of ten and left to dry two days or more before placing in muslin bags. Not more than ten tassels are put in a bag and the bags are always hung up, never laid on a floor or piled up. Every clear day the bagged tassels are taken out and hung up exposed to the sun. If there is a shortage of bags the fuzz is stripped after a week or ten days. In bagging, the fuzz of not more than fifty tassels can be placed in one bag. The bag is tied near the top to make as much space as possible and the fuzz is shaken up every day to prevent packing and to allow some air circulation.
>
> At the beginning of the season the muslin bags used in curing and storing tassels are all sterilized by boiling, and if at any time during the season the slightest musty odor is detected, the bags are sterilized before using again.
>
> During the period of protracted rainy and cloudy weather last December kerosene heaters were kept going continuously in our main store-room of bagged tassels. I believe that the drying effect of these heaters kept some of our best lots of tassels from spoiling during this weather.

During very dry weather fuzz may be planted immediately if collected after all dew has been evaporated. However, as Kutsunai points out, "the tiny seedlings growing out of the seeds sticking firmly to the branches of the tassels are difficult to transplant without much disturbing." When there is a short drying period the fuzz is more easily removed by shaking into a bag or by rolling two or three stems of the tassels between the hands. If it is necessary to pull the fuzz off it usually shows that at least part of the flowers are immature, and seed has not yet been formed.

The cane seed does not keep well. Seed which is in storage for over one month will not germinate well. Seed planted within 10 days of picking will provide the best germinations. Older seed also seems to lack vitality. Just what might be done to prevent this quick deterioration has not been discovered. Nature has not provided the seed with the protective protein covering, etc., which robust seeds have. It is believed that oxidation takes place rapidly and the life germ is soon extinguished. If the keeping qualities of the seed were only good it would be possible to store seed until better growing conditions were provided than are found in the winter season.

Given warm weather, with little overcast sky, and no heavy rains with accompanying moisture-laden atmosphere, the nursery work of germinating and growing the seedlings would be easy. It is seldom that these conditions exist in the months of December and January, and it is unfortunate that seeds will not remain virile but must be planted at that time.

Nursery Technic

The equipments used in the open nursery by those raising 5,000 seedlings or over varied and can best be told by each cane breeder who had to meet different climatic conditions.

Mr. Jennings, working in Kohala from December 4, 1923, to January 29, 1924, when it was necessary to germinate the bulk of the seedlings for the 1924 season, had a nursery at Hawi at an elevation of 625 feet. The mean temperature ranged from 66° to 70° F., and there were heavy winds to complicate all operations. He writes as follows:

I have tried out several different types of cold frames and covers for sun and wind protection at Hawi this year. Three types of glass-covered (one with painted glass) and two of muslin-covered incubators which were electrically heated were tried. These incubators were divided into sections containing about 40 cubic feet of air space and each section was heated by four 100-watt, 110-volt, Mazda lamps. It was possible to keep the temperature up to 70° F. during the coolest nights in the glass-covered incubators with these lamps. The clear glass-covered incubators heated this way gave very good results, while with the painted glass- and muslin-covered type no better results were secured than with the ordinary muslin-covered cold frames.

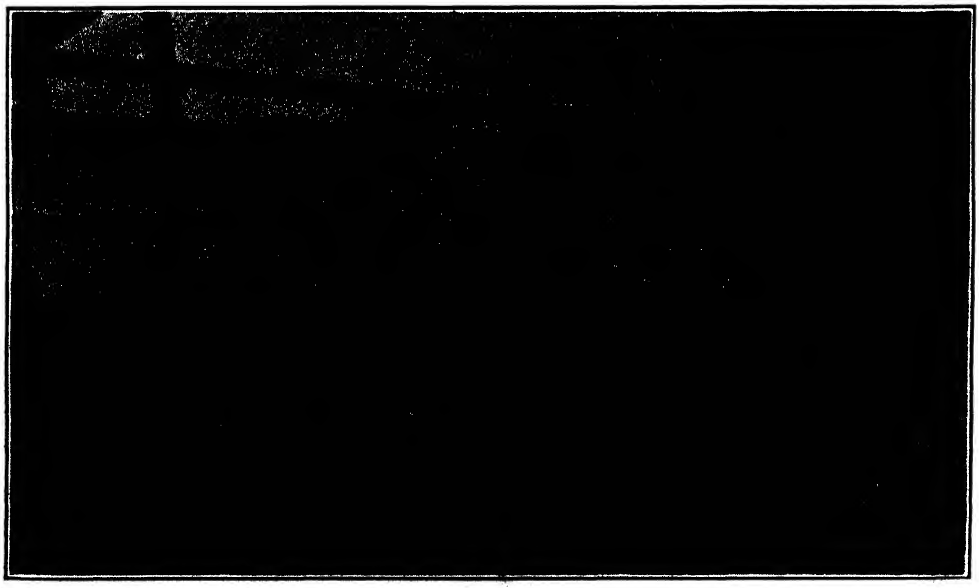

Fig. 1

Fig. 1 shows the glass-covered electrically heated incubator.

Fig. 2 shows the most economical and successful types of covering for germination flats that we have tried yet at Hawi. This bench was built facing the south in

Fig. 2

order to get all the direct sunlight possible into the fuzz flats. The front side is covered with ordinary window sashes, and top and back sides are covered with roofing paper for protection from the wind and rain. With this arrangement the temperature under the glass goes up to over 110° F. on clear days. Several tests comparing germination in the glass-covered frames with that in the muslin-covered frames were conducted. The fuzz planted under glass gave from three to five times heavier germination and in less than half the time required for fuzz from the same lots planted under muslin.

The most satisfactory type of muslin-covered frame for Kohala conditions is shown in Fig. 3. This frame also faces the south. The bench is four feet wide with an eighteen-inch wall at the back. The back wall is for wind protection and the bench is four feet wide, though too narrow to work conveniently, for the reason that with this high backwall a narrower bench would be too dark, especially when the muslin cover is down.

The convenience in weeding and caring for the potted seedlings when grown on the benches will result in a labor saving that will soon pay for the extra cost.

Poole at Eleele and Makaweli, Kauai, and Naquin at Honokaa, were able to accomplish their nursery work without any protection against rain or sun. A windbreak, however, was constructed at Eleele.

Kutsunai, stationed at Makiki, Honolulu, and the writer, at Ewa, used cold frames with cloth covers. The former had some glass covers during the heavy rain storms.

These cold frames, as shown in Figs. 3 and 4, will answer all practical purposes. The writer gave up portable frames, or those on hinges, in place of a roller arrangement which makes an ideal covering. The tent effect sheds water readily and it can be easily raised up on legs as the seedlings grow. During a windstorm, there are no covers to blow loose.

The writer has used many different styles of frames and covers to provide protection from the sun and rain. Under different conditions on Hawaii

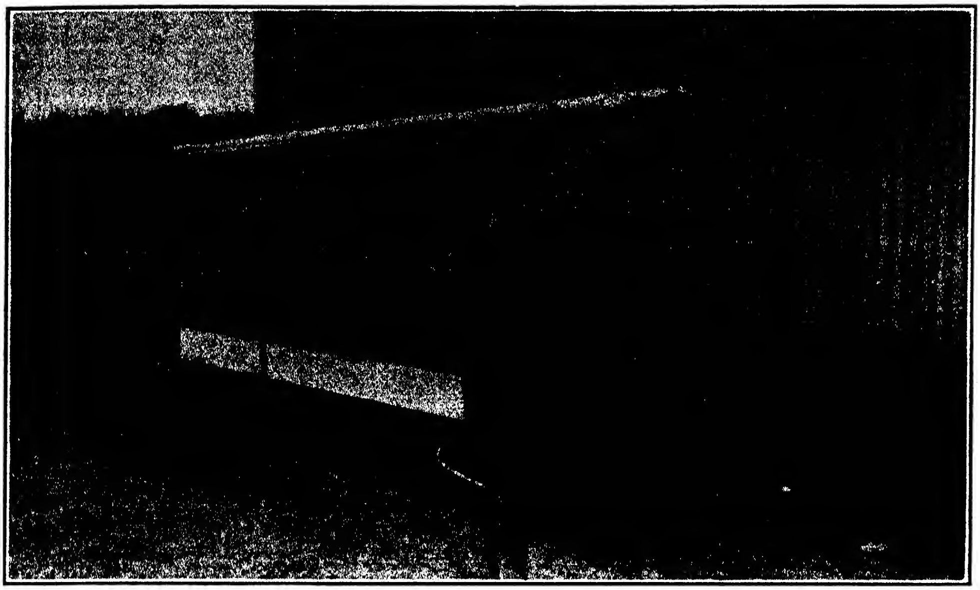

Fig. 3

Fig. 4

he has obtained satisfaction under all conditions from the ones which have painted glass covers, placed about 2 feet above the flats, and made from old windows. They afford good ventilation, and one may easily regulate the amount of direct sunlight the cane is to receive. Such equipment is too expensive when a plantation is propagating seedlings on more than a small scale.

The flats used by Kutsunai at the Experiment Station are 12¾″ wide, 24¼″ long and 2¾″ deep (inside dimensions). The writer has used different sized flats for the plantings, and has finally standardized on one which is 24″x24″x6″. It has the disadvantage of being too heavy for one man to handle by himself when it is filled with soil. Three things are in its favor: (1) It does not dry out as quickly as a narrow, shallow flat does. (2) The depth of soil allows the plants to remain in the flats longer, two months if necessary, without the roots being cramped. (3) Later the boxes are a convenient size to hold 25 pots. It is absolutely essential that enough holes or cracks be made in the bottom of the flats to provide perfect drainage. Nothing can be more harmful than a waterlogged flat.

Jennings finds that "any size or style of flat that has sufficient openings in the bottom for good drainage and that will hold soil to a depth of not less than three inches is O. K." Old flats or flats that have been used recently must be sterilized by being placed in the boiler of the soil sterilizer while soil is being sterilized. He finds much more difficulty in caring for fuzz in old or used flats that have not been sterilized, as the fungus and algae spread very rapidly from the sides of the flats onto the fuzz.

Jennings, Poole and the writer prefer to have flats placed on benches.

The question of what soil to use in the first plantings has been decided by each worker for himself.

Kutsunai, at Makiki, has usually used a mixture of two parts of rich and mellow garden soil and one part coral sand. Poole had success at Eleele with the same soil.

The writer's experience on Hawaii and at Ewa is in agreement with Jennings, who states: "I have had best success by selecting soil that was as free as possible of organic matter. Addition of coral sand to improve the texture of our rather heavy soil and of stable manure or compost for fertility have not been successful. The addition of sand results in a soil mixture of lesser fertility, while stable manure and compost make the control of fungus and algae more difficult."

The richer and more friable the soil is the better are the results obtained from the original plantings. A certain amount of screening of soil is necessary to obtain an even surface.

A most important discovery has been made at Honokaa, in that *decomposed* mud press is an ideal material upon which to lay the cane fuzz. Its fertility, drainage properties, and freedom from algae or green fungus, according to Mr. W. P. Naquin, Manager of Honokaa Sugar Co., should make it acceptable to all cane seedling nurseries. He writes:

During the past year we have made radical changes in the technic of germinating and handling seedlings. On account of high elevation and cold weather we have had some trouble with a green fungus which destroys most of our seedlings before they can be transplanted to the fields. As the sun is one of the best antidotes for this fungus I decided this year to eliminate all artificial protection of young seedlings and let Nature take it's regular course. We have been so successful with this method that we feel it is worthy of a trial in other places. When this natural process is followed, however, we find that water becomes a limiting factor, and unless constant

irrigation is resorted to the cane wilts from the excessive sun. Then, under intensive irrigation the soil becomes soggy and soon we have another condition which is about as bad as the green fungus. After many experiments with different soils we found that decomposed mud press, which contains a considerable amount of wax and lime, is a most excellent soil media in which to grow seedlings.

Owing to the texture of this mud press continuous irrigation does not produce any injurious effects, and it is possible to grow seedlings in the open.

We have tried different proportions of mud press to soil, but in no instance was a combination superior to the straight decomposed mud press.

We have raised some 10,000 seedlings this year at Kukuihaele, with very little loss from damping-off or green fungus. The mud press, aside from being an excellent material for this work, is easy to obtain on all plantations. It should be allowed to rot at least 6 months before it is used, keeping the pile sufficiently damp to allow all fermentation to take place before it is used.

Theoretically, sterilization of the soil is beneficial in that fungus is eliminated. However in actual practice the soil soon becomes reinoculated by the water and exposure to the air. Steaming of the soil, therefore, is done to eliminate grass and weed seeds which will grow during the first weeks, and may be confused with tiny canes. This is especially true of manienie or Bermuda grass. The saving in labor due to freedom from weeds pays for the extra handling of the soil in the sterilizer.

If exhaust steam is available from some engine the sterilization is very simple. A perforated pipe placed in the bottom of an old tank or box upon which the soil in bags is laid and then covered, serves very well. Where steam has to be generated the writer used several schemes, the best of which was a large wash boiler over an open fire upon which several layers of trays filled with soil were placed. The bottom of the trays consisted of a small mesh screen. Baking of the soil is often practiced in other countries, but has a tendency to rob the soil of organic matter.

Planting the Fuzz and Care of Young Seedlings

Nursery work, the growing of any young plants, demands attention to details brought about by special local conditions. Success is the result of very close *personal* supervision of the soil, moisture and heat environment given the germinating seed bed. With proper care fungus troubles are less apt to occur.

Instead of trying to combine the reports received from Jennings, Kutsunai and Poole with the writer's experience, each of the four statements is given in full. The principles involved are:

(1) A fertile soil that will not compact, having good drainage and free from agencies that increase fungus growth.

(2) Optimum moisture conditions determined by careful observations correlated with the conditions of temperature and sunlight.

(3) Taking full advantage of sunlight not only to produce growth but to kill fungus.

Hawi and Kohala, W. C. Jennings:

After much experimenting during the last two seasons I have arrived at the following method of handling fuzz flats.

The fuzz is spread very thickly on the germination flats and pressed down with large quantities of water into a firm, rather tough layer ⅛ to ¼ of an inch thick. The flats are then placed under glass in the frames shown in Fig. 2 and exposed to direct sunlight. The fuzz is watered with a fine spray nozzle two or three times an hour while the sun is shining. On cloudy days it may be necessary to irrigate only two or three times a day. In sunshiny weather I expect the first signs of germination to appear in four or five days. If germination does begin on the fourth or fifth day, by the twelfth day I begin to increase the period between irrigations. In two or three days the number of irrigations are decreased from many light irrigations daily to one or two rather heavy irrigations a day.

The temperature under the glass will go up to over 110° F. with a few hours of sunlight. The fuzz exposed to direct sunlight and in this temperature dries quickly and requires frequent watering. From 9:00 A. M. to 3:00 P. M. on clear days the fuzz flats require almost constant attention, as only enough water to wet down the fuzz is applied at one time. The fuzz is kept constantly moist, yet, so little water is applied each time that the soil in the bottom of the flats will be found almost dry two weeks after planting.

If germination has started on the fourth or fifth day after planting and the young seedlings have not been irrigated too heavily root development will have been well started by the twelfth to fifteenth day. At this stage the periods between irrigations, are gradually lengthened, giving the roots time to get through the fuzz and into the soil before drying out the fuzz too completely. I believe, as a result of having examined the roots of several hundreds of young seedlings, that two or three days is sufficient time for the development of ¼ to ½ inch of root in the seedlings when subjected to this treatment.

The heavy coating of fuzz acts as a mulch and so retains the moisture in the soil beneath that one irrigation a day, except on the very hottest days, is sufficient when once the roots of the seedlings have reached the soil. After the treatment outlined above it is assumed that the roots have reached the soil by the fifteenth to eighteenth days, and irrigation is applied only when the upper part of the fuzz layer has completely dried out. Sufficient water is applied at this stage to soak the soils and then in no case is the flat irrigated again until the fuzz is dried out again. This method of treatment I consider as the most important development in the work at Hawi this year. By this method we have entirely eliminated all trouble with algae, fungus, etc., as the fuzz becomes so dry on top that everything of this order is burned out by the direct sunlight.

There may be some sacrifice of late germinating seed by this method, but vigor of the seedlings already attained will more than compensate for this loss.

In cloudy wather no irrigation is applied until the fuzz dries out even though it be for several days, for as long as there is any moisture at all in the fuzz it can be safely assumed that the soil below has more than sufficient moisture for seedling growth.

Makiki, H. S. P. A., Y. Kutsunai:

Depth of Layer: The fuzz is planted on the soil surface, not in the soil. The thickness of the fuzz planted depends on the germinating capacity of the fuzz. The ordinary run of the fuzz is planted about ¾ of an inch thick before wetting. If the fuzz is very important, it is planted very thin.

Care of Flats—Good Growing Weather—During the First Week: During the first week the fuzz boxes are watered twice a day. The boxes are not covered unless the weather happens to be windy or excessively drying. In most cases, the fuzz is found difficult to keep wet unless covered.

During the Next Two Weeks: At the end of a week after planting the fuzz, tiny seedlings are coming up. They seem to take strong sunlight to good advantage. Sometimes ammonium sulphate in solution is applied at the rate of 3½ grams to a flat.

After Third Week: During this week, the young seedlings become about three-quarter to one inch in height, and they have about three leaves. They are then ready to transplant into another box or pots. The care given to them is essentially the same as the previous week.

Influence of Adverse Growing Conditions: During cloudy weather the covers on the cold frames are kept away, even though the fuzz in the flats is drying a little.

Excessive Moisture Due to Rainfall: Irrigation is cut down.

Cold Nights: The cold frames are covered every night, not for retaining heat, but for protection against heavy rain. No heating is practiced unless the fuzz is a very important one.

Eleele and Makaweli, Kauai. C. F. Poole:

Fuzz was placed in the flats so as to be level with the top of the flat, and shipping tags bearing descriptions of the cane to the windward, the parent tassel, date cut, date planted, and, later on, the date when first shoots appeared, were tacked on the front.

Watering of the flats after planting of the fuzz varied with the germination of the seedlings. No germination was received till the day after Christmas, when warm Kona weather prevailed, and that in flats of D 1135 planted December 10th. A month later some germinations in seedlings of Lahaina occurred in from 7 to 10 days, first appearance, and subsequent germinations continued appearing for about three weeks, with the heaviest occurrence about eleven days afterward. A fine spray nozzle, originally purchased for a bagasse spraying experiment in the mill, was used for irrigations about four times daily until all shoots appeared to have come. After that the flats were watered twice daily until there were about six leaves per shoot. The germinations were much slower than are usually obtained in other localities, seemingly due to the low temperatures on Kauai during December and January nights. The minimum temperature was seldom over 63 degrees until the beginning of April.

There was an unaccountable difference between growing conditions found at Makaweli and at Eleele. Germinations seemed to come sooner at Makaweli, no doubt due to the higher temperature; but after appearance the Makaweli seedlings grew very slowly, while the Eleele seedlings grew straight ahead.

Ewa, W. P. Alexander:

Planting the Fuzz: I do not like to spread the fuzz on the soil too thickly. When the layer is over ⅛ inch (wet) the moisture conditions are more difficult to regulate, as the fuzz dries out quickly and the tender seedlings just starting fail to get their roots into the soil before they dry up. The fuzz needs to be gently pressed on top of the damp soil, but with few exceptions any attempt to cover the fuzz with a thin layer of soil has resulted unfavorably.

I have tried treating the soil before planting with a very weak solution of sulphate of ammonia, but would not recommend it as a general practice. It seemed to stimulate the growth of moss more than it benefited the initial start of the cane.

Care of Seedlings in Flats: Given warm weather, mean temperature of 75° F., night not less than 65° F., the canes will germinate well and without much fussing over them. I find a complete muslin cover for the first 4 to 5 days after planting allows for an easier control of uniform moisture conditions. For the next 10 days, when germination will be most rapid, exposure to direct sunlight must be reduced from 10 a. m. to 2:30 p. m. under Ewa conditions. If weather is cloudy I do not cover at all, as this is the time fungus gets a start and all the light and ventilation possible are necessary. After the third week I try to give as much sunlight as possible without causing the surface moisture to dry out so that the plants wither. No set rule can be given for irrigation. The water should be applied as a fine spray until the plants are large. After germinations have stopped it is better to irrigate only once a day and to cover the flats during the middle of the day than to get the soil so dry that an irrigation is needed then. Each water drop on the leaves at noontime will act as a magnifying lens. The minute burn thus made on the leaf forms a sore spot where fungus will easily attack it. Saline irrigation is harmful when the

salt content is over 50 grains per U. S. gallon. The tender shoots are burned and salt accumulates in the soil to form a toxic condition. Water with 26 grains has been used when no other was available and yet there appeared to be some stunting of growth.

Provided the weather is warm and dry the initial nursery work as described above will be found to present few problems. It is, however, adverse conditions such as:

(1) Cloudy weather without wind causing the rapid increase of fungus, both damping-off and leaf troubles;

(2) Excessive moisture from rains not only benefiting fungus, but also rotting the seed;

(3) Cold nights below 65° F.,

which seem to prevent germination and stunt all growth which may have previously started. Such unfavorable factors keep one's wits alive to coax the germinations and eliminate disease. The above conditions are the rule rather than the exception for certain periods every winter season. The best thing is to get started early enough before the trouble begins. One can nurse a large proportion of cane several weeks old through a bad spell. To overcome the poor environment is another thing working in the open. I have had only fair success, and sometimes complete failure when contending with lack of sunshine, cold days, and nights and excessive moisture in the air. The results of the 1923-1924 season are still fresh in my mind. What appeared to be an unusually good start was turned into a hard fight to pull through one-third of those germinated before the end of December, and practically no germinations were secured from 150 flats planted afterwards.

When growing conditions are worst, the moisture must be kept at a minimum. Some method of sub-irrigation would be ideal, so that water would not be applied on the surface. Use must be made of every bit of sunlight. Every effort must be made not to interfere with a good air current through the flats. In spite of these precautions the algae will grow and fungus will get a hold. The little plants seem to have no resistance to disease when their vitality is at a low ebb.

My experience with any form of incubation has shown that it must be done for a short period, say not over five days after planting and then the change to nursery conditions and ordinary temperatures and light must be gradual. Very often the plants that are thus forced will not grow to be strong healthy seedlings.

Differences in Germination

There is a great difference in the percentage of germination one secures. Sometimes the flats will be literally green with the tiny shoots, and again one is fortunate to get a dozen seedlings to a flat. There also appears to be much variation in the vigor of the little canes. Very often the most prolific seeds will have weak-growing canes. This is also true in India. Varieties that are not commercial canes will give seedlings that lack vigor from the start.

Kutsunai has made the following notes on germination of the fuzz:

> In glass houses, the flats containing approximately the same quantity of one lot of cane fuzz germinate differently according to the place given them in the glass houses. The boxes near the east, the south, and the west side germinate much better than those in the central position.
>
> The age of the tassels, or the interval between the cutting and the planting of the tassels, affects germination very much. The tassels heat up when packed closely, before drying. The fuzz from such tassels does not germinate well. Early cut tassels germinate better than late cut tassels. Ripe tassels germinate better than overripe tassels.

Transplanting Seedlings and Care of Potted Seedlings

The methods adopted in transplanting are more uniform, although here too the personal element influences the mode of procedure.

Ewa, W. P. Alexander:

For several seasons on Hawaii, after trying out transplanting the cane when three or four weeks old into a second flat, the writer has had for three years at Ewa, good success with direct potting of the seedlings when about six leaves had appeared, thus eliminating one step and saving much labor. The mortality is less when there is only one transplanting. Even so, one must expect some dying out as a result of root disturbance, if the seedlings have germinated closely together.

The kind of soil used in the pots has a decided influence on the growth the plants make. A soil mixture with a leaf mould compost will have the splendid moisture holding capacity and the new roots spread rapidly in the good tilth.

During the time it takes the roots to get adjusted the plants must be kept in the shade.

A mulch of some kind over the surface of the soil in the pots prevents drying out of the surface and minimizes the growth of fungus. I have used black sand (volcanic ash) and rice paddy for this purpose.

After the plant has taken hold in the pot, its growth can be stimulated by applying a small pinch of sulphate of ammonia. The response is immediate and lessens the period they must remain in the nursery.

Eleele and Makaweli, C. F. Poole:

Transplanting from the flats to the paper pots, which were of asphalt felt, 15" x 6", fastened with paper clips, was done when the seedlings had about six leaves. Each pot was then marked with waterproof crayon, showing the flat number from which obtained.

The soil used in the pots was the ordinary field soil, which had previously been worked up like a garden patch, spread over with a layer of manure about one inch deep, and washed down with a hose several times before the raw manure was removed.

At Eleele a pinch of ammonium sulphate (A. & B. half and half) was added to the seedlings when growth was resumed after recovering from the shock of transplanting. This recovery varied with individuals and with the time of transplanting. During March it was about forty days, and in June about fifteen days. At Makaweli a small quantity of sodium nitrate was dissolved in water, making a very weak solution, and a few drops were added to the revived seedlings.

No mulch was used in the pots.

Makiki, Y. Kutsunai:

If the fuzz flat is crowded, the bigger seedlings are transplanted rather early, in order to make room for the others. In about four weeks after germination, the seedlings are large enough to transplant to other flats or pots. They are about three-quarters to one inch high and have three leaves.

The soil is composed of one part sand, one part compost, and two to three parts of garden soil. One part well rotted stable manure and one part soil was tried with good results.

Hawi, Kohala, W. C. Jennings:

I transplant in case of either very light or of very heavy germination. If there are but few germinations per flat, too many flats would be needed to care for the desired number of seedlings. If germination is very heavy the seedlings will become too crowded

before reaching the potting stage. When the number of germinations per flat runs from 50 to 100 the seedlings are grown to the potting stage in the germination flats.

The seedlings are transplanted when from 1½ to 2 inches high. I find that the mortality is very high when seedlings smaller than this are transplanted.

The seedlings are shaded for several days after transplanting. After having been shaded from 7 to 10 days, several days more are spent breaking the seedlings into full time exposure to direct sunlight.

When it is necessary to use stable manure or compost in the transplant flats a closely compacted layer about an inch thick is placed on the bottom of the flats and covered with two inches of soil. If the manure is mixed with the soil there is more apt to be trouble with fungi, etc., especially during the period immediately after transplanting when the seedlings must be shaded.

The seedlings are transplanted to pots when from 6 to 8 inches high. My soil mixture for potting is one part manure with three parts of ordinary field soil. The seedlings are shaded and then gradually broken in to exposure to direct sunlight in the same manner as first transplanting.

As soon an the seedlings have recovered from the effects of the potting operation and have started up a good growth, all wind protection is removed. This checks the growth in all the seedlings for a time and while some fail to grow after this check others soon recover and make a vigorous growth. All plants which fail to recover and start up a good growth within 6 to 8 weeks are weeded out.

Control of Insects in the Nursery

Cutworms: Mr. Kutsunai recommends either spraying with lead arsenate solution about once every two weeks or hand picking. Jennings and the writer have found spraying ineffective against cutworms. Continuous hand picking is the only remedy.

Mites and Thrips: Mr. Jennings and the writer have used nicotine sulphate to good advantage. One spraying must be followed in a few days by a second to kill the newly hatched insects.

Control of Fungus: Mr. H. Atherton Lee, pathologist of the Experiment Station, H. S. P. A., recommends a Bordeaux mixture dust for the control of green algae, upon which the fungus gets a start.

Nursery Technic in Other Sugar Countries

Through the cooperation of the cane breeders in other sugar producing countries, the writer is able, through correspondence, to present digests of the methods employed in the nursery. The portion of the quotations which are in italics are ideas which are of particular interest to us and where methods are mentioned might be worth a trial.

I. India

Extract from article written specially for the Committee on Varieties by T. S. Venkatraman, Government Sugar Cane Expert, Coimbatore:

Sowing and Germination: For sowing, shallow, circular country earthenware pans, 12" across at top, 9" at bottom and 6" high, have been found satisfactory. Previous to sowing, the pans are numbered with some waterproof paint. Suitable provision having been made for free drainage at bottom, the pans are filled with a mixture of equal parts of well-rotted horse dung and sand. The fluff is now laid in an even thin layer on the

surface and the first watering done from a garden hose held 3 feet above the pans. The force of the impact gathers round the tiny seeds a small amount of soil and this facilitates germination. The quantity of water employed should not be of such as to form a pool in the pan as it leads to the seeds all getting to one side and germination is affected. Immediately after sowing the pans are arranged in groups, each group containing all the pans of a particular lot, and each group is separately labelled with details as to variety sown, date of sowing and other details. *For this purpose paper labels first written in pencil or India ink and subsequently dipped in melted paraffin wax have been found useful; they are unaffected by the frequent watering.* Germinations have not been noticed earlier than three days from sowing; and pans not germinating within a fortnight have rarely been found to do so later.

Watering: At Coimbatore, it has been found necessary to water the pans as often as three to four times during the day. The watering is always done through a garden hose. For proper germination it has been found necessary to keep the fluff always moist. After germination the plants need much less water as the roots quickly develop and traverse a good bit of soil. The young cane plants are often very susceptible to excess of water and quickly turn yellow.

Precautions During Early Stages: It has been found useful to place the seedling pans on raised bamboo platforms about 2½ to 3 feet from the ground. Besides facilitating constant inspection of the young plants, the arrangement is of use against ants and crickets. *It has been found best to place the seedlings in full sun. The young sugar cane plants appear to revel in full sun and are rather susceptible to any kind of shade. In one instance the circular shade from a cocoanut crown marked off a corresponding circle of weak and unhealthy plants in the pans placed under it.*

Weeding and Thinning of Sown Pans: The appearance of a large number of grass seedlings, which in the earlier stages look much like those of the cane and hence are difficult to weed out is a trouble of some importance. At Coimbatore, the two weeds chiefly met with in the pans are *Chloris barbata* and *Cynodon dactylon.* It was found that the number of these could be greatly minimized if the horse dung, which is apparently the chief source of infection, is pitted for a couple of months before use and periodically watered. The heat generated in the pits appears to cause the death of the grass seeds. As an additional precaution the filled pans are allowed to remain unsown from ten to twelve days and occasionally watered during the period. The grass seedlings that come up are pulled out and the pans are now ready for sugar cane growing. The very few grass seedlings that appear even after the above precautions are easily removed by trained laborers. Should the pans be found very crowded, and contain, say, more than two or three hundred seedlings, they need pricking after a fortnight into a second set of pans. If the germination is thinner the pans may be left till they are ready for planting in the first ground nursery.

II. Java

Extracts from translation of Handbook of Sugar Cane Culture, Chapter VII, page 323:

'*Seeding, Nursing and Planting Out:* The flowers may now be planted right away by picking the small ears or by letting the individual little flowers drop off, or by leaving the entire flowers in a box out in the sun. Naturally a wind-still place must be selected, as otherwise too much of the seeds are lost. In the early morning when there is no wind, the woolly mass is spread out on a previously prepared spot where the soil has been loosened and powdered. This spreading out in a thin layer can best be done with a thin rod, which is a much quicker way than to put down each individual flower. The seed is then pressed in the soil with a small board and covered with fine soil from a sieve, just enough to keep the seed down. Too deeply buried seed does not germinate. When this is

done water is applied from a sprinkling can with small holes, and this must be repeated daily and often enough to prevent the seed from drying out.

Moquette began with the seed spread out in boxes with sand, kept in the shade and well moistened. After four days the first germs appeared, but many of the small plants withered in a few days. They received too little sunshine, and experienc showed later that they did better in heavy soil than in the river sand.

Therefore, when seedling cane, a fertile soil, plenty of moisture and sunshine are first essentials.

Seeding may also be done on plots directly on the field, but moles and other vermin can easier be kept out when the seed is put in boxes. Preferable for use are the flat boxes, large pots or the flat square clay trays such as first used by Souit. To facilitate controlling the trays they may be put up on a framework which at the same time protects the tiny plants from the attack of the many insects living on the surface of the soil. It eliminates carrying back and forth of loose covers.

Application of stable manure, however desirable for young plants, is bothersome on account of the large number of weeds that must quickly and repeatedly be removed. This is again undesirable because the young cane shoots resemble so closely the grass plants that only a trained eye can see the difference. Therefore it is better to sprinkle the soil with a weak solution of ammonia or nitrate of soda, either previous to seeding, or a few days later. For strength a tablespoonful in a kerosene can is sufficient. This may be repeated several times if necessary. The beneficial effect may easily be noticed by observing the dark green coloring and the quicker growth of the plants. Although the number of weedings may thus be reduced, it cannot be eliminated altogether. To do this most effectively is by means of a pair of scissors; the germinating sprouts of the double seed lobe plants must be cut just a little under the seed lobes, and those of the grasses right under the soil. Doing it this way prevents loosening of the soil, and the young cane shoots escape harm. Another way of avoiding the germination of weeds is by preparing the trays a long time beforehand and working the soil over. The weeds do not then get a chance to come through. The soil must be kept moistened.

III. Philippine Islands

Reply to questionnaire received from Professor N. B. Mendiola, University of the Philippines, College of Agriculture, Los Banos, Laguna:

I am using two kinds of seed boxes for germination and pre-transplanting cultures—a shallow one where the soil is about 10 cm. (4 inches) deep for germination and a deeper one where the soil is not less than 15 cm. (6 inches) deep for pricking the seedlings into. Both are of the same length and width, are easily obtained by dividing a Standard Oil petroleum box into two, and providing the sides, which were once the top of the box with covers. The soil I use is rich in organic matter and *is first sterilized on an open pan above a fire.* The germination boxes are fully exposed to direct sunlight more than half of the day. The fuzz is shaken off the arrow or pulled off it and allowed to drop onto the surface of the soil in the seed box. The seeds are sown thickly, covering practically all the surface. The box is then watered thoroughly and covered with a piece of glass. Watering is done subsequently every day, morning and afternoon, or often enough to keep the box moist. *The glass is not whitewashed. However, a piece of cloth covers the top of the glass. This cloth is used to maintain a desirable amount of sunlight in the box and is rolled up when the sun is not too bright to heat the seed and seedlings to the wilting or danger point.* As stated elsewhere, germination is done in the shallower box. As fast as the seeds germinate they are picked into boxes where the soil is 15 cm. or more deep. These boxes are 35 x 49 cm. in the inside and contain 24 pricked seedlings each. I have so far made no determination of percentage of germination. The seedlings are allowed to grow in these boxes until transplanted into nursery rows in my Plant Breeding Garden. At transplanting time the

seedlings are about 35-40 cm. high. I have not done any fertilization work either when the seedlings are in the boxes or in the nursery rows or when these are in propagation cultures in the field. Provided the newly transplanted seedlings are given sufficient water every day there is no need of covering them from too intense sunlight. When water is not available in sufficient quantities for watering the seedlings, I found it necessary to cover the newly transplanted seedlings with pieces of the false stem of the banana plant until the plants are recovered.

IV. Mauritius

Reply to questionnaire by C. A. O'Connor received from H. Temparary, Director of Agriculture:

The boxes employed for sowing seeds are from ordinary empty kerosene cases cut in two. They are about 1′ 9″ long and 1′ 2″ wide and 5″ high, there are a certain number of holes at the bottom for drainage. *A layer of small gravel is placed at the bottom to prevent the soil clogging drainage holes.* These boxes have the advantage of being light, they can be easily carried about by one man, even after having been filled with soil.

The soil used is always burnt in order to destroy grass and weed seeds. The cane seedlings can easily be recognized as soon as they appear, by the tendency they have of growing in a slanting position.

Germination is very liable. Some varieties, especially those raised from seeds, will themselves yield very fertile seeds, whilst others, like the "White Tanna," give poor results. It has been noticed that seeds of the same variety collected from different districts give different results. Those collected from one locality yielding hundreds of seedlings and those from another place one or two plants or often none at all. This is attributed to the effect of wind and rain at the time of flowering. As a rule tassels obtained from a dry district are more fertile than those from a wet one.

When the boxes are ready the fuzz is spread thinly on the soil. It is then pressed gently with the hand and covered with a thin layer of fine coral sand. After sowing the boxes are watered with a garden syringe giving a fine spray, in order not to disturb the seeds. The boxes are placed on stone or iron shelves as a protection against hares, tenrecs (Centetes sps.), snails, etc.

The sand prevents the soil cracking and baking. We do not find that it promotes the growth of fungi, if there is proper drainage. The boxes are at times covered with glass panes to check evaporation. They are watered from time to time. The soil must be kept moist, but not too damp. Germination begins about 15 days after sowing.

When the seedlings are about a month old, they receive a pinch of sulphate of ammonia to stimulate growth.

The seedlings are transplanted into bamboo or earthenware pots when they have five or six leaves. Only healthy plants are selected, all weak ones are discarded.

Insects and fungi are kept in check by application of tobacco, Bordeaux mixture or other sprays.

When seedlings appear to be getting too big for their pots, they are again transplanted in the field in rows 5′ apart and 2½′ in the rows.

V. Fiji

Extract from article given to writer personally by H. F. Clark, Agriculturist, Colonial Sugar Co.:

Soil is a rich alluvial-loam. It is sieved through a fine-meshed sieve and baked, i. e., it is kept for about half an hour on an iron plate over an open fire at a temperature at which slight charring occurs in the organic matter it contains. ***It is then cooled, put into***

boxes, and worked up with liquid manure for a couple of weeks before being used. The "fuz" is sown by spreading it evenly over the surface of the dry soil and pressing it well down. It is watered several times a day for the first few days. Germination begins in 3 or 4 days; is at its best in 7 or 8 days, and is generally completed in 14 days.

Germination: Germination and early growth are carried out in a glass-house. This is merely a suntrap, and is not steam-heated. The temperature ranges from 90° F. to 120° F. during the daytime, but it drops to between 60° F. and 70° F. during the night.

Potting Out: When the seedlings are 1"-1½" high they are planted out into 6" pots. They are kept a few more days in the glass-house, and are then transferred to cold frames. They are covered with canvas at night till the seedlings have hardened a little.

Planting Out: When the seedlings are 8"-12" high, they are planted out into the field into drills 5' apart. The seedlings are set out at 5' from one another in the drills.

Manuring: Sulphate of ammonia is occasionally applied before the seedlings are potted out. A very light dose is given while they are in the pots, and a somewhat larger one after they have been planted out in the field for a few weeks. No other fertilizer is used. The first land into which the seedlings are planted is a rich alluvial-loam.

VI. Australia

Reply to questionnaire received from H. T. Easterby, Director Bureau of Sugar Experiment Stations, Queensland:

We use shallow boxes of rich, loamy, porous, sterilized soil; pull fuzz to pieces over the boxes; percentage of germination from 5 to 80 per cent, according to warmth of season. Use glass covers with cheese cloth. On very clear days a double cover is used. We transplant at 4 months into large boxes with about 8 inches of soil. We do not use fertilizer.

VII. Porto Rico

Reply to questionnaire received from T. F. Saldana, Assistant Horticulturist, Porto Rico Agricultural Experiment Station, Mayaguez:

Mode of procedure in the nursery: Flats 14¼" x 19" x ⅜" are used. Five holes are made in the bottom of each flat for drainage. For planting the fuzz we use sandy loam river soil which has been passed through a one-fourth inch mesh sieve. The flats are filled with this soil and then packed back to within 1 inch of the top edge. They are watered so that when the fuzz is planted it will stick to the soil. The fuzz is shaken all over the flats until a uniform thin layer, not more than ¼ inch thick, is obtained; they are then watered again with a watering can having a fine nozzle so as to pack down the fuzz. The packing down is also done with the palm of the hand. We have tried covering the fuzz with a very fine layer of finely screened soil, but observation shows us that a stronger germination is obtained when no covering is used. In order to avoid mixing the planting is done in a draft proof house, and each variety when planted is taken out immediately before fuzz from another is seeded down. Watering is done twice a day, morning and night. Germination begins at from 6 to 17 days, depending on variety and vitality of seed used.

The young seedlings have been submitted to different conditions during the past year. A shed house partially covered with palm leaves did not serve the purpose on account of the fact that during rains the water fell in big drops, disturbing the soil around the seedlings. A glass roof green house, the walls of which consisted of ¼ inch mesh netting wire, has given good results. After the seedlings have been transplanted to boxes or pots we seldom give them extra protection. For transplanting the young seedling from the seed flats we have used bamboo pots, and 10-inch clay pots. Also flats of the same

dimensions as those used for germinating the seed are used, planting 20 seedlings to each pot, but on account of the expense of using thousands of pots, we have adopted the flats for most of the work. The seedlings are transplanted when they are from 1 inch to 1½ inch high, i. e., when they are about one month old. The soil we use for transplanting the seedlings consists of 2 parts river loam and 1 part stable manure. The seedlings are watered twice a day for the first week and from then on only once daily. They are watered about once or twice a week with nitrate of soda water at the rate of 4 grams to a gallon of water. They are grown about a month under these conditions and then transplanted to the field, in rows 5 feet apart and with 3 feet between the plants in the rows.

VIII. British Guiana

Notes by F. X. Williams, November, 1923, at Sugar Planters' Experiment Station at Sophia, Georgetown, Mr. T. J. Crabtree, Superintendent:

Apparatus and Methods: Seeds are taken off the "arrows." Seedling boxes, good size, 2 inches or so deep. Soil used sterilized so as to eliminate the growth of weeds. *Bottom of box filled with coarse burnt earth lumps, finer above this and finally fine soil.* Seeds laid mat-like on top and then preferably weighted down with a little sand. In 5-6 days seedlings appear; *those late in germinating are weaklings.*

Cane Loaders*

By B. W. Mackie

The most practical device used in loading cane into cars in the field has proven to be a full revolving crane, or derrick, mounted on a tractor base of the crawler or continuous tread type. The cane is bundled or piled onto a pair of single slings lying on the field, and the bundles lifted by the crane, swung around to the car and dropped. The slings are removed after being unhooked, and pulled free from the bundle by the crane.

The machine itself consists essentially of a *tractor* or *crawler base,* on which are grouped the traveling and steering mechanisms controlled by the operator from the operating platform on the rotating base. The *rotating base,* mounted on the tractor base, contains the *power plant, hoisting and swinging mechanisms,* the *control levers,* and a *boom* approximately forty feet long, capable of being raised or lowered as desired.

In getting over the fields it is important that the machine have sufficient effective length and breadth supporting it, so that it will be stable. Ten by ten feet seems to be about the accepted size. Taking this as a basis from which to build a strong and rugged machine, it is found that the total weight will be somewhere between 20 and 25 tons. To move this weight over the field with as little damage as possible, the crawler type tread must have sufficient supporting surface to dis-

* Presented at the Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

tribute the total weight over a large area. The bearing pressure on the ground should not exceed 10 pounds to the square inch.

Cane loaders of this type are not limited to just this one class of work, as they may be used for operating a clamshell bucket, dragline scraper bucket, hook block, pile driver hammer, electric lift magnet, etc. Nearly every type made may be converted into a power shovel, by taking off the crane boom and substituting a boom having the proper equipment for this work. The machine can then be used for the same work that a steam shovel would be used.

Essential Machine Parts

Power Plant: The power plant of a cane loading crane usually consists of a heavy duty tractor type gasoline engine having four cylinders. It should develop sufficient power at a normal speed to drive the machine anywhere it would be expected to work. All its parts must be built rugged and strong, with special reference to accessibility and perfect lubrication. It is important that an air cleaner be installed ahead of the carburetor to insure against grit and dirt entering the engine. A clutch should be installed between the engine and operating mechanism so all gears and shafts may be stopped with the engine still running. The power plant should be mounted on the main frame in such a manner that all strains are not directly transmitted to the engine base. The drive to the reduction gears should be as flexible as possible. An efficient cooling system is imperative.

Drive From Power Plant: Because of the fact that a gasoline engine develops its power at a relatively high speed, a means of reducing this speed to that required for hoisting, swinging, and traveling, must be employed. This reduction is accomplished usually by gears. Special attention should be paid to securing a drive which will give perfect service in operation.

Rotating Mechanism: The rotating frame is swung to right or left by a pinion engaging in a ring gear fastened to the travel base. The rotating pinion, through a series of reductions, receives its power from a reversing shaft driven from the reducing gears. Where only one reversing shaft is employed, a jaw clutch is mounted on the rotating shaft so that it may be disengaged, and the reversing shaft used for traveling. There is no necessity in this work to perform swinging and traveling simultaneously, so the use of two separate sets of reversing clutches is done away with. One set, through selective jaw clutches, enables the operator to handle the machine under all operating requirements. Simplicity of design and accessability for repairs is important.

Hoisting Mechanism: The hoisting mechanism consists of drums independently driven by friction clutches, loosely mounted on shafting driven from the reduction gears. Where both drums are mounted on one shaft, the design is simplified by the elimination of a shaft, bearings and a gear, and makes other assemblies easier to get at. It is necessary to see that the drums be of sufficient size to properly coil the two hundred feet of one-half-inch cable, commonly used for hoisting.

The Propelling Mechanism: This drive is taxed with the hardest service at all times. It must be rugged and contain the least number of pinions, gears, and shafts possible. It must be constructed so that repairs in the field can be readily made. The drive is taken from the reversing clutches, through several gear reduc-

tions and the center pin of the machine, to the travel base, and finally to the crawler treads themselves. The final drive to the treads is either through gears or a roller chain. The chain drive is the most flexible and easiest to repair, and in addition gives adjustment of the tread belt at either end of the travel base.

Rotating Base: The main rotating member is called upon to withstand severe shocks due to traveling over uneven footing, ditches, etc., and is preferably made of a solid annealed steel casting, from which the supports for the main machinery are built up.

Travel Base: The travel base, which must be built very rugged and strong, consists of a *heavy main casting*, preferably steel, the *supporting axles or beams* for the crawler treads, and the *ring gear* securely attached to the casting. Avoid any machines that have built-up structural bases for the main parts of either the rotating or traveling bases.

Center Pin: The travel base and rotating base are tied together by means of a hollow steel gudgeon or center pin, which must be of the best material obtainable and heavy enough to afford a good margin of safety. There must be provided a convenient means for taking up wear at this point of the machine.

Treads: There are many types of crawler mechanisms, but the ones that most closely follow approved tractor ideas will be found to be most satisfactory.

General: It is, of course, highly important that workmanship and careful design enter into a machine of this nature, to insure the greatest degree of service. Interchangeability of parts is also an important feature. Levers and controls must be placed so that all operations can be conveniently performed by the operator from his platform. Proper lubrication of all bearings is essential to insure long life and continued service. The use of frictionless bearings on high speed shafts and gears is to be recommended. Placing the operator so that he commands an unobstructed view on all sides and providing controls that will operate with the least physical effort, will make possible performing the greatest amount of work. Adjustments must be provided at all points in the controls to compensate for wear.

Cane Field Conditions From the Standpoint of Machines

Traveling: Cane loaders in the field are subjected to the hardest kind of service, in that they are moving from car to car a great percentage of the time, under unfavorable ground conditions. Furrows, irrigation ditches, and water course ditches, encountered at all times, necessitate a strongly built foundation, and only the best construction will endure. It is important that the machines go over the fields with as little disturbance as possible, and with despatch. Quite frequently the machines are called upon to work on a grade, and some form of brake on the travel mechanisms is required, or they must be blocked to prevent rolling down grade.

The longer the effective surface of the crawler mechanism on the ground, the more stable will the machine be. A short crawler tread will, in effect, give a rocking-horse motion to the machine when traveling across the field. As the field furrows are five feet or more center to center, it will be seen that about ten feet of tread length is desirable.

The treads and driving parts should be so designed as to pick up as little cane trash and refuse lying on the field as possible. This is especially important in wet weather operations.

Careful handling and well-planned setting of the correct number of cars for the amount of bundles to be loaded is essential to satisfactory performance. Requiring the machines to go back over a section already "taken off" to load a few cars can be laid only to bad field management, and works a hardship on the machines because the time taken up in traveling cuts down the total number of cars that can be loaded in one day. Wherever possible, it is advisable to load cane only from the side of the cars on which the machines are traveling.

Steering: Field conditions demand that when turning and steering, the machines do as little damage to the furrows and ratoons as possible. To handle properly they must steer positively to right or left when traveling in either direction, and at the easy command of the operator. A thoroughly successful and practical steering device controlled from the rotating base of the machines is, of course, a necessity. Many machines have a crude and unsatisfactory steering device.

Lifting: All the present machines used in this service have been designed for much heavier work than they are called upon to do in loading cane, so there is a good margin of safety in the hoisting mechanism, and very little trouble, if any, is encountered. A good boom-head construction, for guiding the cable with a minimum of wear, is essential. Also, it is important that the cable wind up properly on the drum with as little attention on the part of the operator as is consistent.

Swinging: It should be the aim of the operators to keep their machines as level as possible when loading cane, so that they will swing easily. This is not always practical in service, so that a powerful, yet easy working, swinging mechanism should be incorporated in the construction. To stop the swinging of the machine, the reversing clutches are thrown in, in the opposite direction, and this should be done in such a manner that the motion is not stopped immediately. After getting the load in motion it should be permitted to coast and be brought to a gradual stop. Gauging the position of the machine with reference to the car to be loaded assists greatly in smooth handling.

Conclusion: The commercial success of the jib crane type of cane loader has been assured by the past season's use at the Oahu Sugar Co., Waipahu; Kahuku Plantation Co., Kahuku; Honolulu Plantation Co., Aiea; The Hawaiian Sugar Co., Makaweli; and Lihue Plantation Co., Lihue. The machines unquestionably relieve the severest manual work on the plantations, and if for no other reason, they are a step in the right direction. The mechanical loaders enable the plantations using them to harvest the cane faster than by hand methods. The use of them assures a train load of cane at the mill earlier in the day. Cane may be bundled in the field whether cars are placed or not, and the cars are kept in actual load hauling a greater percentage of the time.

Cane Varieties*

A Resume of the Plantings for the 1924 Season.

By W. P. Alexander.

The Committee on Varieties submits its report in the form of a survey of the varieties planted and those plowed out during 1924. In this way attention is focused on those commercial varieties and new seedlings which are meeting popular approval under different growing conditions, and those whose acreage is on the decrease. Your committee believes that such publicity on the trend in variety plantings as given in the following notes and statistics should stimulate interest in securing the right variety for each specific environment. Basing our opinion on the results secured from H 109, we feel justified in stating that the greatest opportunity for advancement in the agricultural side of the industry is through the breeding and selection of the best varieties.

In preparing this report the cooperation of the different managers has been secured, and the following committeemen have assisted materially: Oahu, F. A. Paris and Y. Kutsunai; Maui, W. W. G. Moir and Frank Broadbent; Hawaii, J. C. Thompson.

The data have been divided into two sections, viz:

(1) Commercial plantings of varieties.

(2) Experimental plantings of varieties.

It is treated geographically, for it is the conditions on the different Islands and on the individual plantations that determine what variety is to be planted. The relative distribution of each variety taken as a whole throughout the Islands is of less practical importance to each one of us, than the definite knowledge of what varieties are being grown successfully under certain climatic, soil, and moisture conditions.

COMMERCIAL PLANTINGS

Island of Kauai

Yellow Tip. The outstanding feature in the 1924 variety plantings on the island of Kauai is the replacing of Yellow Caledonia and D 1135 on the mauka lands by Yellow Tip. A total of 2,462.39 acres have been planted to this hardy variety. This represents 32.1 per cent of all the varieties planted. Striped Tip finds less favor, Kilauea, only, planting 63 acres.

All the plantations on the northeast side of the island of Kauai have begun planting their unirrigated lands with Yellow Tip. To quote Mr. John T. Moir, Jr., of Koloa, "Its vigor, stand, and growth rates all point toward a decided eclipse of the old reliable Yellow Caledonia."

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

H 109. As on Oahu and Maui, H 109 is fulfilling all the requirements where irrigation is practiced. There are 4,239.74 acres planted to H 109, which area is replacing mainly Yellow Caledonia, Lahaina, D 1135 and H 146. This represents 55 per cent of all the 1924 plantings on Kauai.

There are not many commercial plantings of other varieties besides H 109, Yellow Tip, and D 1135, which combined account for 89 per cent of the area.

D 1135. D 1135 is "losing ground" with 516 acres plowed out and 222 acres planted during 1924. It will be noted that but 41 acres were started on the windward side of the island. The exposed fields of McBryde occupy the only plantings on the leeward side.

Only 275 acres of Yellow Caledonia are being planted as against 4,874.69 being discarded. Certainly the "death knell" of this old standard variety seems to be sounded on Kauai.

Badila covers a total of 118 acres as plant 1926 cane at Grove Farm, Kipu, and Kilauea. It is not a very popular variety for several reasons, the chief of which is its low fiber content and susceptibility to rat damage.

Uba is being given a trial on 64 acres at Kilauea.

H 20 is being carried on in a small area of 20 acres at Gay & Robinson.

Of the newer Hawaiian seedlings H 456 is being watched. Although the Oahu plantations have found it unsuitable, certainly in the Lihue district it is worth being watched. Kipu planted 50 acres, Grove Farm 5 acres, Makee 18 acres. It will be interesting to observe the ratooning qualities of H 456 on Kauai.

H 463 also is ready to be graduated into the commercial class on this part of Kauai. In tests at Grove Farm good yields have been secured from H 467 and H 468.

ISLAND OF KAUAI.

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924.

Plantation	H 109	Yellow Tip	Yellow Cal.	D 1135	Mixed	Badila	H 456	Uba	Str. Tip	H 20	H 463	Str. Mex.	Total Area
Kekaha	450.00	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	450.00
Waimea	No Plant Cane			.....	.....	.....	.....	.....	.....	.....	.....	.....	......
Gay & Robinson	283.00	......	.....	.....	.....	.....	.....	.....	.....	25.00	.....	.....	308.00
Hawaiian Sugar	790.00	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	790.00
McBryde	430.00	9.00	15.00	181.00	32.00	.....	.....	.....	.....	.....	.....	5.00	672.00
Koloa	511.00	296.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	807.00
Kipu	10.00	120.00	.....	.....	.....	70.00	50.00	.....	.....	.....	.....	.....	250.00
Grove Farm	158.00	245.00	136.00	20.00	36.00	20.00	8.00	.....	.....	.....	8.00	.....	631.00
Lihue	657.74	692 39	124.55	.....	121.01	.....	.....	.....	.....	.....	.....	.....	1,595.69
Makee	800.00	422.00	.....	.....	.....	.....	18.00	.....	.....	.....	.....	.....	1,240.00
Kilauea	150.00	678.00	.....	21.00	.....	28.00	.....	64.00	63.00	.....	.....	.....	1,004.00
Total Area	4,239.74	2,462.39	275.55	222.00	189.01	118.00	76.00	64.00	63.00	25.00	8.00	5.00	7,747.69
% Area	54.72%	31.78%	3.56%	2.87%	2.44%	1.52%	.98%	.83%	.81%	.32%	.10%	.07%	

NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924.

Plantation	Yellow Cal.	La-haina	D 1135	H 109	H 146	H 20	Badila	H 227	Fallow or New Land	Total Area
Kekaha	......	450.00	.....	.....	.....	.....	.....	.....	......	450.00
Waimea	......	.....	.....	No Data		.....	.....	.....	......	......
Gay & Robinson	......	70.00	131.00	34.00	24.00	1.00	15.00	13.00	20.00	308.00
Haw. Sugar	......	.....	300.00	.....	100.00	39.00	9.00	.....	342.00	790.00
McBryde	228.00	.....	85.00	352.00	.....	.....	.....	.....	7.00	672.00
Koloa	807.00	.....	.....	.....	.....	.....	.....	.....	......	807.00
Kipu	......	.....	.....	.....	.....	.....	.....	.....	250.00	250.00
Grove Farm	......	.....	.....	.....	.....	.....	.....	.....	631.00	631.00
Lihue	1,595.69	.....	.....	.....	.....	.....	.....	.....	......	1,595.69
Makee	1,240.00	.....	.....	.....	.....	.....	.....	.....	......	1,240.00
Kilauea	1,004.00	.....	.....	.....	.....	.....	.....	.....	......	1,004.00
Total Area	4 874.69	520.00	516.00	386.00	124.00	40.00	24.00	13.00	1,250.00	7,747.69
% Area, Excluding Fallow	75.02%	8.00%	7.94%	5.94%	1.91%	.62%	.37%	.20%	......	

Island of Oahu

H 109 is without question now the standard variety on Oahu. Its leadership among the varieties is shown when, during 1924, 98 per cent of all the plant area, of seven plantations reporting, was in H 109. Ewa plantation replaced 616.31 acres of old H 109 ratoons with the same variety, which is evidence that the variety has no rival there.

D 1135 was not planted anywhere, while 608.35 acres were plowed out. H 146 lost 257.46 acres and none planted.

Yellow Caledonia was plowed out on 1,679.18 acres, and Lahaina on 1,538 acres. They represent 65 per cent of the area plowed out and there will soon be very little of either variety on the island of Oahu.

Of the newer seedlings H 8958 was spread to 2 acres on Oahu Sugar Co. and Wailuku No. 2 was planted to 5 acres at Kahuku.

ISLAND OF OAHU *

NUMBER OF ACRES PLANTED TO DIFFERENT VARIETIES DURING 1924

Name of Plantations	H 109	Y. C.	Wailuku 2	Lahaina	H 8958	Seedling Nurseries	Total
Honolulu Plantation	1,061.00	.....	.....	.....	2.00	1.25	1,064.25
Oahu Sugar	1,086.43	.....	.....	.....	.....	.....	1,086.43
Ewa Plantation	604.86	.....	.....	.....	.....	21.25	626.11
Waialua Agricultural	1,646.60	.....	.....	.....	.....	.....	1,646.60
Kahuku	373.75	.....	5.00	3.25	.....	3.00	385.00
Laie	85.00	57.50	.....	.....	.....	.....	142.50
Koolau Agricultural	100.00	.....	.....	.....	.....	.....	100.00
Total Acreage*	4,957.64	57.50	5.00	3.25	2.00	25.50	5,050.89
Per cent of Acreage*	98.16%	1.14%	0.10%	0.06%	0.04%	0.50%	

* No acreage data from Waianae and Waimanalo.

ISLAND OF OAHU *

NUMBER OF ACRES PLOWED OUT OF DIFFERENT VARIETIES DURING 1924

Name of Plantation	Y. C.	Lahaina	H 109	D 1135	H 146	Badila	Mixed	Fallow or New Land	Total
Honolulu Plantation	948.00	19.00	.....	96.00	....	....	.....	1.25	1,064.25
Oahu Sugar	......	671.94	.....	330.14	72.85	11.50	.....	.....	1,086.43
Ewa Plantation	......	4.41	616.31	.....	....	....	.....	5.39	626.11
Waialua Agricultural	215.18	842.71	.....	182.21	184.61	....	221.89	.....	1,646.60
Kahuku	339.00	......	.....	.....	....	....	.....	46.00	385.00
Laie	77.00	......	.....	.....	....	....	.....	65.50	142.50
Koolau Agricultural	100.00	......	.....	.....	....	....	.....	.....	100.00
Total Acreage*	1,679.18	1,538.06	616.31	608.35	257.46	11.50	221.89	118.14	5,050.89
Percentage of variety areas plowed out*	34.05%	31.18%	12.49%	12.33%	5.22%	.23%	4.50%		

* No acreage data from Waianae and Waimanalo.

Island of Maui

The stronghold of Lahaina has fallen to H 109. The Maui plantations, which sent in data, report 91 per cent or 5,166.43 acres planted to H 109 with but 2 per cent or 108 acres planted to Lahaina.

Striped Mexican was spread to 258 acres, with 454.2 acres plowed out.

Badila was planted to 25 acres.

Rose Bamboo, H 146, D 1135 and Yellow Caledonia are being rapidly discarded.

On a small scale newer seedlings such as Wailuku 2 and Wailuku 4 are finding favor.

ISLAND OF MAUI *

NUMBER OF ACRES PLANTED TO DIFFERENT VARIETIES DURING 1924

	H 109	Striped Mex.	Lahaina	D 1135	Badila	W-2	W-4	Mixed	Total
Maui Agri.....	1,570.00	250.00	95.00	.....	25.00	.....	.....	.....	1,940.00
H. C. &. S. Co..	1,521.00	.....	13.00	16.00	.....	.....	.....	.....	1,550.00
Pioneer.......	1,500.00	8.00	.....	.....	.....	.....	.....	5.00	1,513.00
Olowalu.......	24.50	.....	.....	.....	.....	.....	.....	.....	24.50
Wailuku......	550.93	.....	.....	55.16	.....	25.00	20.00	6.00	657.09
Total Acreage*	5,166.43	258.00	108.00	71.16	25.00	25.00	20.00	11.00	5,684.59
% of Acreage..	90.88%	4.54%	1.90%	0.44%	1.25%	0.20%	0.44%	0.35%	

* No acreage data from Kaeleku.

ISLAND OF MAUI *

NUMBER OF ACRES PLOWED OUT OF DIFFERENT VARIETIES DURING 1924

	Lahaina	H 109	D 1135	Bamboo	Str. Mex.	Y. C.	H 146	Fallow or New Land	Total
Maui Agricultural....	615.00	311.00	72.00	221.00	124.00	52.00	....	545.00	1,940.00
H. C. & S. Co........	323.00	401.00	163.00	.....	.....	.....	.....	663.00	1,550.00
Pioneer	933.00	22.00	.....	.....	.....	8.00	25.00	525.00	1,513.00
Olowalu	22.00	.....	.....	.....	2.50	.....	.....	.....	24.50
Wailuku	49.56	.....	.....	.....	327.70	63.24	68.85	147.74	657.09
Total Acreage*	1,942.56	734.00	235.00	221.00	454.20	123.24	93.85	1,880.74	5,684.59
Percentage of variety areas plowed out*...	51.07%	19.30%	6.18%	5.81%	11.94%	3.24%	2.46%		

* No acreage data from Kaeleku.

ISLAND OF HAWAII—KAU DISTRICT

D 1135 and Yellow Caledonia continue to remain the standard varieties of the Kau district, planting 52.5 per cent and 47.5 per cent respectively of the 1924 area. At Pahala, where cane is grown at the highest elevations, Yellow Caledonia has given 70 tons of cane at 2,000 feet elevation, and D 1135 the same yield at 2,600 feet.

Rose Bamboo, Yellow Bamboo and White Bamboo are being plowed out. The Tip canes have not found favor in the Kau district.

ISLAND OF HAWAII—KAU DISTRICT

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924

Plantation	D 1135	Yellow Caledonia	Total
Hutchinson	120.00	298.60	418.60
Hawaiian Agricultural	424.04	192.95	616.99
Total Acres	544.04	491.55	1,035.59
Percentage of Total	52.53%	47.47%	

NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924.

Plantation	Rose Bamboo	Yellow Bamboo	White Bamboo	Striped Tip	Yellow Cal.	Total
Hutchinson	220.60	.....	.....	60.00	25.00	305.60
Hawn. Agric....	......	98.00	97.00	.....	.....	195.00
Total Acres	220.60	98.00	97.00	60.00	25.00	500.60
% Area	44.07%	19.58%	19.38%	4.99%	11.98%	

Island of Hawaii—Hilo District

Makai lands: No cane has been found equal to Yellow Caledonia for the greater part of the Hilo district. From Olaa to Laupahoehoe it was planted this season as it has been for the past 20 years on all the lower and middle fields. No special complaint is made as to its virility taken as a whole, and no seedling has risen to dispute its supremacy.

Mauka lands: On the other hand, a variety is needed that will suit the upper fields as well as Yellow Caledonia does the lower elevations. D 1135 was the most common variety planted this year for these conditions with Yellow Tip running second. There is some difference of opinion as to which variety is to be preferred. It seems that Yellow Tip plantings are on the increase, except at Hakalau, from which place Mr. Geo. Ross, Assistant Manager, writes, "We are trying to get away to a certain extent from Yellow Tip and getting into D 1135. We harvested as high as 60 tons of cane per acre at 1,200 feet elevation with a quality ratio of about 8.5." At Onomea, Yellow Tip is sometimes planted on the knolls and Yellow Caledonia in the hollows. It is considered better than D 1135 and is now being rotated with Yellow Caledonia on mauka fields.

The plantations along the Hilo coast realize that they should add to their three standard commercial varieties Yellow Caledonia, D 1135 and Yellow Tip.

The following notes on 1924 plantings show canes that are passing beyond the experimental stage:

At Waiakea, Badila (4 acres), Waiakea No. 1 (1 acre), H 109 (1 acre), H 8958 (1 acre) were planted in 1924.

At Hilo Sugar Co., H 389 (4.14 acres), H 109 (1.02 acres) and Badila (.5 acre) were planted in 1924.

At Onomea, there are H 456, H 469, H 471, H 472 and Wailuku No. 2.

At Honomu, there were extended this year Badila (2 acres), D 117 (8 acres), Striped Mexican (1 acre), White Bamboo (2 acres) and Rose Bamboo (2 acres).

At Hakalau, H 109, H 456, H 457 and H 463 are mentioned. Most of the above canes are doing well on the high elevations. H 227 is being discarded in the Hilo district, especially at Olaa.

ISLAND OF HAWAII—HILO DISTRICT.

NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924 (Incomplete).

Plantation	Y. C.	H 227	Striped Tip	Yellow Tip	Total
Pepeekeo	591.00	.....	.....	9.00	600.00
Hilo Sugar Co.	431.87	.....	.....	.....	431.87
Waiakea	320.50	0.5	22.00	.....	343.00
Olaa	......	124.00	.....	.....	124.00
Total Area 4 Plantations	1,343.37	124.50	22.00	9.00	1,498.87
% Area	89.63%	8.30%	1.47%	0.60%	

No data on acreage plowed out from Hawaii Mill, Onomea, Honomu, Hakalau and Laupahoehoe.

ISLAND OF HAWAII—HILO DISTRICT

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924 (Incomplete)

Plantation	Yellow Caledonia	D 1135	Yellow Tip	Mixed	D 117	Badila	H 389	Black Tanna	H 109	White Bamboo	Rose Bamboo	Waiakea No. 1	H 8958	Striped Mexican	H 456	Uba	Total Area
Waiakea	782.00	15.00	19.00	2.27	...	4.00	...	3.00	1.00	...	...	1.00	1.00	...	...	...	828.27
Pepeekeo Sugar	541.00	25.00	34.00	....	...	...	...	...	...	...	...	...	...	...	...	...	600.00
Olaa	348.00	178.00	....	....	...	...	...	...	...	...	...	...	...	...	...	...	526.00
Hilo Sugar Co.	264.50	153.18	8.00	.53	...	.50	4.14	...	1.02	...	...	...	...	...	...	...	431.87
Honomu Sugar	.....	28.00	21.00	8.00	8.00	2.00	...	...	...	2.00	2.00	...	...	1.00	1.00	.50	73.50
Total 5 plantations*	1,935.50	399.18	82.00	10.80	8.00	6.50	4.14	3.00	2.02	2.00	2.00	1.00	1.00	1.00	1.00	.50	2,459.64
% Area	78.70%	16.23%	3.33%	.44%	.33%	.26%	.17%	.12%	.08%	.08%	.08%	.04%	.04%	.04%	.04%	.02%	

* No data on acreage of each variety planted during 1924 from Hawaii Mill, Onomea, Hakalau and Laupahoehoe.

Island of Hawaii—Hamakua District

The 1924 plantings in the Hamakua district consisted mainly of D 1135 (61 per cent), Yellow Tip (23 per cent), Yellow Caledonia (12 per cent) and Uba (2.3 per cent). They replaced chiefly Yellow Caledonia (44.5 per cent), D 117 (37.5 per cent), D 1135 (8.54 per cent), Striped Tip (5 per cent) and H 109 (4 per cent).

The choice of varieties depends largely on the elevation and mosaic disease conditions on the plantations. Yellow Caledonia is not planted much above the 600-foot elevation and D 1135 may be put in on the lower lands, and also going as high as 1,200 feet. Yellow Tip seems to be a favorite for the highest fields, except at Honokaa and Pacific Sugar Mill where yellow stripe disease or mosaic is prevalent. Uba, which is resistant to mosaic, is being tried to meet these conditions, and appears to have passed the experimental stage at Honokaa, as the following comparative yields with D 1135 show:

Variety	Crop Area	Cane	Q. R.	Sugar
Uba	.60	68.30	16.33	4.14
D 1135	139.00	37.92	9.56	4.17
Difference		+30.38	— 6.77	+0.03
Uba	9.00	47.7	8.01	5.67
D 1135	137.00	35.6	7.84	4.57
		+12.1	— 0.17	+1.10

Yellow Caledonia is being replaced at Paauhau with the more hardy cane, D 1135.

H 72 was spread to 2 acres at Paauhau and H 349 to 5 acres at Kaiwiki.

At Honokaa, several new promising seedlings appear on the horizon. An unselected seedling of the 1917 Oahu propagation No. 229 now known as Honokaa No. 1 is planted to 15 acres. The new Uba-D 1135 Hybrid No. 1 now covers 4 acres at Honokaa and Pacific Sugar Mill.

ISLAND OF HAWAII—HAMAKUA DISTRICT

NUMBER OF ACRES PLANTED TO DIFFERENT VARIETIES DURING 1924

Plantation	D 1135	Yellow Tip	Yellow Caledonia	Uba	Honokaa No. 1	D 117	Seedling Nursery	H 349	Uba Hybrid	H 72	Total Acres
Kaiwiki	504	55	205	....	...	12	...	5	...	...	781
Hamakua Mill...	480	256	150	....	...	...	...	...	...	...	886
Paauhau	426	343	...	....	...	...	...	...	...	2	771
Honokaa	30	....	...	50	15	...	6	...	2	...	103
Pacific Sugar.....	300	....	...	16	...	...	3	...	2	...	321
Total Area	1,740	654	355	66	15	12	9	5	4	2	2,862
% Area	60.81%	22.85%	12.40%	2.31%	.52%	.42%	.31%	.17%	.14%	.07%	

NUMBER OF ACRES PLOWED OUT TO DIFFERENT VARIETIES DURING 1924

Plantation	Yellow Caledonia	D 117	D 1135	Striped Tip	H 109	H 75	H 349	Badila	Fallow or New Land	Total Acres
Kaiwiki	432	185	25	118	....	6	3	...	12	781
Hamakua Mill	....	740	....	....	....	...	...	...	146	886
Paauhau	426	....	185	....	....	...	...	...	160	771
Honokaa	2	....	....	....	15	...	...	1	85	103
Pacific Sugar	236	....	....	....	85	...	...	...	...	321
Total Area	1,096	925	210	118	100	6	3	1	403	2,862
% Area Without Fallow	44.57%	37.62%	8.54%	4.80%	4.07%	.24%	.12%	.04%		

Island of Hawaii—Kohala District

The variety situation in Kohala did not change much during the 1924 season. Periodic dry spells make it absolutely necessary to have a drought-resistant variety of cane. H 109, therefore, can only be planted where irrigation is practiced. Even Yellow Caledonia is not able to withstand the extreme droughts as it once did. D 1135 for the middle and lower section and Yellow and Striped Tips for the upper fields compose the commercial plantings for 1924. The presence in Kohala of mosaic and red stripe diseases which attack the Tip canes makes it very important that a substitute that will do equally as well as Yellow and Striped Tip be found.

ISLAND OF HAWAII—KOHALA DISTRICT.
NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924 (Incomplete).

Plantation	Y. C.	Striped Tip	H 109	D 1135	Striped Mex.	Total
Hawi Mill	235.00	265.00	177.00	107.00	4.00	788.00
Union Mill	60.00	.....	.....	.....	.....	60.00
Total Area	295.00	265.00	177.00	107.00	4.00	848.00
% Area	34.79%	31.25%	20.87%	12.62%	0.47%	

No data on varieties plowed out during 1924 from Niulii, Halawa and Kohala.

ISLAND OF HAWAII—KOHALA DISTRICT

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924 (Incomplete)

	Striped Tip	D 1135	Yellow Tip	H 109	Mixed	Uba	Total Area
Union Mill	484.00	63.00	....	....	...	...	547.00
Hawi Mill	139.00	263.00	85.00	50.00	7.00	1.50	545.50
Total area*	623.00	326.00	85.00	50.00	7.00	1.50	1,092.50
% Area	57.02%	29.84%	7.78%	4.58%	.64%	.14%	

* No data on acreage of each variety planted during 1924 from Niulii, Halawa and Kohala.

Experimental Plantings for 1924

The experimental work on varieties is largely in the hands of the Experiment Station of the H. S. P. A. They may furnish the varietal material, but they must rely on the plantations themselves to undertake the testing under different field conditions. After it has passed the experimental stage the development of new varieties on a commercial scale rests entirely with the plantations.

The disappointments in new seedlings have been so many that caution is needed in not letting one's enthusiasm for a "pet seedling" run wild. A thorough trial on large enough areas of repeated plots, with check areas of a standard variety, is necessary to secure proper comparisons. Fields of plant cane are very misleading. Time is required to get the ratooning qualities with sucrose content of a seedling growing to maturity in 20 months, but such information is very important. There would be less overrating of new seedlings if more patience were exercised and one waited for harvesting data together with comparative yield of the adjacent standard variety. It is not merely enough that a variety looks "promising," its sucrose content, ratooning qualities, disease resistance, and time of maturity must be known.

The following notes are not a complete digest of the variety work being done. Unfortunately the replies to the committee's questionnaire on new seedlings were very brief. Nevertheless, there is a very good indication of the present status of the Hawaiian seedlings:

Older "H" Seedlings (Excluding H 109)

Kauai—

H 20 is the only one of the older "H" seedlings which is reported as being spread during 1924, 25 acres being planted on Kauai at Gay & Robinson.

Concerning this variety Mr. Sinclair Robinson writes as follows:

> For early season harvesting our H 20 has in a number of instances proved better than adjoining areas of H 109. As our fields are harvested each year prior to April 1, we have therefore considered it advisable to continue further experiments with the variety H 20. Lack of good top seed, however, makes it a difficult cane to start, but so far our ratoon fields have fully compensated for the additional expense in planting.

H 146 will soon be extinct at the rate large areas are being plowed out.

Oahu and Maui—

None of these older Hawaiian canes are being experimented with as plant cane for 1926. Large areas of H 146 were plowed out at Oahu and Waialua and a small acreage at Pioneer.

Hawaii—

Several "H" seedlings of the first series were planted in 1924.
H 72—Paauhau (no harvesting data).
H 349—Waiakea and Ookala (no harvesting data).
H 389—Hilo Sugar Co. reports the following test:

	Cane	Q. R.	Sugar
H 389 plant	72.49	8.94	8.45
H 389 first ratoon	67.29	8.76	7.67
2 crops average	69.89	8.85	8.06
Yellow Caledonia plant	67.02	8.29	8.11
Yellow Caledonia first ratoon	64.98	8.73	7.44
Average	66.00	8.51	7.78
Average gain H 389	+3.89	—0.34	+0.28

H 227 is being plowed out in 1924 on many fields.

"400" Series

Kauai—

H 456. In 1924 the following areas were planted: McBryde, 2 acres; Kipu, 50 acres; Grove Farm, 5 acres; Makee, 18 acres.

Grove Farm reports the following tests with H 456 and Yellow Caledonia:

Variety	Crop	Cane	Q. R.	Sugar
H 456	Plant	76.0	8.39	9.06
H 456	Short ratoon	34.14	7.19	4.75
Average 2 crops		55.07	7.79	6.91
Yellow Caledonia	Plant	73.1	8.78	8.32
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Average 2 crops		54.62	8.48	6.37
Average gain for H 456		+0.45	+0.69	+0.54

H 457. A test at Grove Farm with Yellow Caledonia is reported:

H 457	Short ratoon	41.97	8.57	4.90
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Gain for H 457		+5.84	—0.39	+0.48

H 458. A test at Grove Farm is reported:

H 458	Short ratoon	38.50	8.29	4.64
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Gain for H 458		+2.37	—0.11	+0.22

H 463. A test at Grove Farm is reported:

H 463	Plant	70.1	8.54	8.21
H 463	Short ratoon	47.70	7.53	6.33
Average		58.90	8.04	7.27
Gain for H 463 over Yellow Caledonia		+4.28	+0.44	+0.90

H 467. A test at Grove Farm is reported:

H 467	Plant	67.1	9.84	6.82
H 467	Short ratoon	45.71	8.15	5.61
Average		56.41	9.00	6.22
Gain for H 467		+1.79	—0.52	—0.15

H 468. A test at Grove Farm is reported:

H 468	Short ratoon	42.96	8.14	5.28
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Gain for H 468		+6.83	+0.04	+0.86

H 469. A test at Grove Farm is reported:

Variety	Crop	Cane	Q. R.	Sugar
H 469	Plant	67.3	9.38	7.17
H 469	Short ratoon	46.79	9.66	4.84
Average		57.05	9.52	6.01
Gain for H 469 over Yellow Caledonia		+2.43	—1.04	—0.36

Oahu—

H 456. Owing to its poor ratooning qualities this variety has not been spread on Oahu during 1924.

A test at Ewa showed this variety cannot compete with H 109.

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	106.28	7.63	13.93
H 456	Plant	78.63	7.80	10.08
Gain for H 109		+27.65	+0.23	+3.85

Also at Waipio H 456 failed in 2 crops.

H 109	Plant	77.4	7.44	10.40
H 109	First ratoon	93.3	7.37	12.62
Average 2 crops		85.4	7.41	11.51
H 456	Plant	65.1	7.38	8.82
H 456	First Ratoon	85.9	8.07	10.64
Average 2 crops		75.5	7.73	9.73
Gain for H 109, average 2 crops		+9.9	+0.32	+1.78

H 468. This seedling was compared with H 109 at Ewa in the following test:

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	101.50	7.66	13.25
H 468	Plant	93.89	7.76	12.10
Gain for H 109		+7.61	+0.10	+1.15

H 471. A test at Ewa with H 109 yielded:

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	146.97	8.31	17.69
H 471	Plant	92.80	8.14	11.40
Gain for H 109		+54.17	—0.17	+6.29

H 472. A test at Ewa comparing H 472 with H 109 gave:

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	145.39	8.67	16.77
H 472	Plant	87.39	8.28	10.55
		58.00	—0.39	6.22

Maui—

H 456. Pioneer Mill Company—No harvesting data.
H 463. Pioneer Mill Company—No harvesting data.
H 471. Pioneer Mill Company—No harvesting data.
H 472. Pioneer Mill Company—No harvesting data.

Hawaii—

H 456. Pahala—No harvesting data—good growth.
Olaa—No harvesting data—good growth.
Waiakea—No harvesting data—good growth.
Onomea—No harvesting data—good growth.

Honomu—No harvesting data—good growth.

Hakalau reports the following test giving a good gain for H 456 over Yellow Caledonia:

Variety	Crop	Cane	Q. R.	Sugar
H 456	Plant	66.09	7.53	8.78
Yellow Caledonia	Plant	40.91	7.91	5.17
Gain for H 456		+15.18	+0.38	+3.61

H 457. Hakalau has secured good results at a high elevation in cane yield but poor juice from H 457.

Variety	Crop	Cane	Q. R.	Sugar
H 457	Plant	76.22	11.05	6.90
Yellow Caledonia	Plant	58.52	7.91	7.39
Gain for H 457		+17.70	—3.14	—0.49

H 463. Hakalau finds H 463 a promising high land cane in this test:

Variety	Crop	Cane	Q. R.	Sugar
H 463	Plant	71.53	7.90	9.05
Yellow Caledonia	Plant	56.10	7.91	7.09
Gain for H 463		+15.43	+0.01	+1.96

H 468. Pahala (No harvesting data—good growth).
H 469. Onomea (No harvesting data—good growth).
H 471. Onomea (No harvesting data—good growth).
H 472. Pahala (No harvesting data—good growth).
H 472. Onomea (No harvesting data—good growth).

"5900" Series

Kauai—

No seedling of the "5900" series has been reported on from Kauai as being especially promising and none have been spread in 1924.

Oahu—

No large areas have been tried out on Oahu of these seedlings during 1924. Harvesting data at Ewa showed them inferior seedlings to H 109.

H 5978.

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	162.59	8.58	18.95
H 5978	Plant	108.76	8.69	12.51
Gain for H 109		+53.83	+0.11	+6.44

H 5986.

H 109	Plant	149.65	9.55	15.67
H 5986	Plant	125.38	9.79	12.81
Gain for H 109		+24.27	+0.24	+2.86

Maui—

H 5946. Pioneer (No harvesting data—promising).
H 5949. Pioneer (No harvesting data—promising).
H 5974. Pioneer (No harvesting data—promising).
H 5978. Pioneer (No harvesting data—promising).

Hawaii—

H 5949. Waiakea (No harvesting data).
H 5953. Honokaa reports test with D 1135.

Variety	Area	Cane	Q. R.	Sugar
H 5953	.01	47.0	6.84	6.87
D 1135	.01	42.0	7.33	5.83
Gain for H 5953		+5.0	+0.49	+1.04

H 5965. Pahala (No harvesting data—good growth).
Waiakea (No harvesting data).

H 5972. Waiakea (No harvesting data).
Honokaa harvested a test of H 5972 with D 1135.

Variety	Area	Cane	Q. R.	Sugar
H 5972	.01	53.9	6.83	7.87
D 1135	.01	42.0	7.33	5.83
Gain for H 5972		+11.9	+0.50	+2.04

H 5973. Honokaa also tested out H 5973 with D 1135, securing 5 tons of cane per acre more.

Variety	Area	Cane	Q. R.	Sugar
H 5973	.01	47.0	7.61	6.22
D 1135	.01	42.0	7.33	5.83
Gain for H 5973		+5.0	—0.28	+0.39

H 5995. Honokaa reports a test on H 5995.

Variety	Area	Cane	Q. R.	Sugar
H 5995	.01	52.2	8.65	6.04
D 1135	.01	42.0	7.33	5.83
Gain for H 5995		+10.2	—1.32	+0.21

Seedlings of 1918 Kauai Propagation

(Raised by R. S. Thurston.)

Kauai—

Makaweli 1. Hawaiian Sugar Co., no harvesting data.
Makaweli 3. Hawaiian Sugar Co., no harvesting data.
McBryde 1. McBryde Sugar Co., no harvesting data.
McBryde 2. McBryde Sugar Co., no harvesting data.

Seedlings of 1917 Oahu Proparation

At Makiki.

(Raised by J. S. B. Pratt, Jr., and Y. Kutsunai.)

Oahu—

O. P. 268. Ewa reports a test:

Variety	Cane	Q. R.	Sugar
H 109	145.35	7.66	18.97
No. 268	126.45	8.77	14.42
Gain for H 109	+18.90	+1.11	+4.55

O. P. 347 (Ewa 800). Ewa reports two tests:

Variety	Cane	Q. R.	Sugar
H 109	168.33	8.88	18.95
Ewa 800	150.10	8.05	18.65
Gain for H 109	+18.24	—.75	+0.30

Variety	Cane
H 109 (Short plant)	63.93
Ewa 800	60.90
Gain for H 109	+3.03

O. P. 394. (Ewa No. 801). Ewa reports a test:

Variety	Cane	Q. R.	Sugar
Ewa 801	116.32	8.25	14.10
H 109	107.60	8.09	13.30
Gain for Ewa 801	+8.72	—0.16	+0.80

Maui—

O. P. 11. Pioneer, no harvesting data, reports good growth.
60. Pioneer, no harvesting data, reports good growth.
78. Pioneer, no harvesting data, reports good growth.
287. Pioneer, no harvesting data, reports good growth.
347 (Ewa 800). Pioneer, no harvesting data, reports good growth.
349 (Ewa 801). Pioneer, no harvesting data, reports good growth.
746. Pioneer, no harvesting data, reports good growth.

Kauai—

O. P. 229 (Honokaa No. 1). Grove Farm, no harvesting data.

Hawaii—

Honokaa has tested out these seedlings on a small scale and has spread O. P. 1917 229, or Honokaa No. 1, to 15 acres. The yields follow:

Variety	Cane	Q. R.	Sugar
O. P. 11	39.2	6.46	6.06
D 1135	42.8	7.33	5.83
Gain or Loss for O. P. 11	—3.6	+0.87	+0.23
O. P. 124	46.0	7.23	6.36
D 1135	42.8	7.33	5.83
Gain for O. P. 124	+3.2	+0.10	+0.53
O. P. 134	42.8	7.28	5.88
D 1135	42.8	7.33	5.83
Gain for O. P. 134	....	+0.05	+0.05
O. P. 176	39.6	6.68	5.92
D 1135	42.8	7.33	5.83
Gain or Loss for 176	—3.2	—0.65	+0.09
O. P. 229 (Honokaa No. 1)	25.8	8.93	2.77
D 1135	24.7	8.19	3.15
Gain or Loss for 229	+1.1	—0.74	—0.38
O. P. 719	45.8	6.59	6.94
D 1135	42.8	7.33	5.83
Gain or Loss for 719	+3.0	+0.74	+1.11
O. P. 748	42.3	7.20	5.88
D 1135	42.8	7.33	5.83
Gain or Loss for 748	+0.5	+0.13	+0.05

Seedlings of 1917 Maui Propagation

(Raised by J. T. Moir, Jr., at Wailuku.)

Kauai—

Wailuku 2. McBryde, no harvesting data, reports good growth.
Wailuku 2. Koloa, no harvesting data, reports good growth.
Wailuku 4. McBryde, no harvesting data, reports good growth.
Wailuku 9. Koloa, no harvesting data, reports good growth.
Wailuku 10. McBryde, no harvesting data, reports good growth.
Wailuku 11. Koloa, no harvesting data, reports good growth.
Wailuku 13. Koloa, no harvesting data, reports good growth.

Oahu—

Wailuku 2. Kahuku, no harvesting data, reports good growth.

Wailuku 2. Ewa reports harvesting test on 10 months old cane:

Wailuku 2	48.82 cane per acre
H 109	47.36 cane per acre
Gain for W 2................	1.46 cane per acre

Wailuku 11. Ewa reports test on 10 months old cane:

H 109	62.85 cane per acre
Wailuku 11	57.03 cane per cane
Gain for H 109	5.82 cane per acre

Wailuku 13. Ewa reports test on 10 months old cane:

Wailuku 13	66.32 cane per acre
H 109	62.85 cane per acre
Gain for W 13..............	3.47 cane per acre

Maui—

The seedlings have been spread rapidly and except at Wailuku no harvested experiments show how the seedlings rank. The Experiment Station monthly letter of June 7, 1924, gives some comparative yields with H 109 from which the following is taken:

Variety	Cane	Q. R.	Sugar
W 2	109.4	10.71	10.21
H 109	99.9	7.60	13.12
Gain or Loss for W 2........	+9.5	—3.11	—2.81
W 4	90.3	8.25	10.94
H 109	102.4	7.60	13.54
Gain or Loss for W 4........	—12.1	—0.65	—2.60
W 11	126.1	8.93	14.11
H 109	99.1	7.60	13.02
Gain or Loss for W 11.......	+27.0	—1.33	+1.09

Herewith follows a list of the Wailuku seedlings being extended to larger areas and considered worth further trial at the places mentioned:

Wailuku 1 —H. C. & S. Co., Wailuku, Pioneer.
Wailuku 2*—H. C. & S. Co., Wailuku, Olowalu, Pioneer.
Wailuku 4*—H. C. & S. Co., Wailuku, Maui Agricultural, Pioneer.
Wailuku 5 —Wailuku.
Wailuku 6 —Wailuku.
Wailuku 9*—Maui Agricultural, Wailuku.
Wailuku 11*—Wailuku, Pioneer.
Wailuku 12 —H. C. & S. Co., Olowalu, Pioneer.
Wailuku 13 —Wailuku.
Wailuku 15 —H. C. & S. Co., Olowalu, Pioneer.
Wailuku 16 —H. C. & S. Co.
Wailuku 17 —Pioneer.
Wailuku 21*—Pioneer.
Wailuku 23*—Pioneer.
Wailuku 26 —H. C. & S. Co.
Wailuku 42*—Pioneer.
Wailuku 47 —H. C. & S. Co.
Wailuku 49*—H. C. & S. Co., Wailuku, Pioneer.
Wailuku 50*—H. C. & S. Co., Wailuku, Olowalu, Pioneer.
Wailuku 51*—Wailuku, Pioneer.
Wailuku 54 —Maui Agricultural.
Wailuku 55*—H. C. & S. Co., Pioneer.
Wailuku 56 —H. C. & S. Co.
Wailuku 57 —Wailuku.
Wailuku 62*—Pioneer.
Wailuku 64*—H. C. & S. Co., Pioneer.
Wailuku 65 —H. C. & S. Co.
Wailuku 66 —H. C. & S. Co.
Wailuku 67 —H. C. & S. Co.
Wailuku 68 —H. C. & S. Co.
Wailuku 69 —H. C. & S. Co.
Wailuku 70 —H. C. & S. Co.
Wailuku 71*—H. C. & S. Co.
Wailuku 72 —H. C. & S. Co.
Wailuku 73*—Wailuku, Pioneer.
Wailuku 74*—H. C. & S. Co.
Wailuku 75*—H. C. & S. Co.

* Including 28, 29, 30, 43, 44, 58 recommended for trial under different environments by Mr. W. W. G. Moir.

Hawaii—

Wailuku 1. Waiakea, no harvesting data.
Wailuku 2. Waiakea, no harvesting data.
Wailuku 2. Onomea no harvesting data.
Wailuku 2. Hilo Sugar, no harvesting data.
Wailuku 4. Waiakea, no harvesting data.
Wailuku 6. Waiakea, no harvesting data.
Wailuku 10. Waiakea, no harvesting data.

Seedlings of 1917 Hawaii Propagation

(Raised by W. P. Alexander at Kohala and Hilo.)

Kauai—

Kohala 117. Grove Farm, no harvesting data.
Kohala 202. Grove Farm, no harvesting data.

Hawaii—

Kohala 4. Kohala Sugar Co., no harvesting data.
Kohala 4. Waiakea Mill, no harvesting data.
Kohala 73. Kohala Sugar Co., no harvesting data.
Kohala 107. Kohala Sugar Co., no harvesting data.
Kohala 107. Waiakea Mill, no harvesting data.
Kohala 115. Kohala Sugar Co., no harvesting data.
Kohala 117. Waiakea Mill, no harvesting data.
Kohala 117. Kohala Sugar Co., no harvesting data.
Kohala 202. Waiakea Mill, no harvesting data.
Kohala 202. Kohala Sugar Co., no harvesting data.
Waiakea 1. Waiakea Mill, no harvesting data.

"8900" Series

H 8901. Pahala (No harvesting data), reports good growth.
H 8906. Pahala (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Waipio (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
H 8948. Kahuku (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8948	128.52	9.10	14.12
Gain for H 109	+17.25	+0.88	+3.61

H 8954. Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
H 8958. Pahala (No harvesting data), reports good growth.

Waiakea (No harvesting data), reports good growth.
Kahuku (No harvesting data), reports good growth.
Waialua (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Ewa (No harvesting data), reports only fair ratoons.

H 8961. Kahuku (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Waiakea (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.

H 8965. Pahala (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Waialua (No harvesting data), reports good growth.
Waipio (No harvesting data), reports good growth.
Kahuku (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8965	108.42	8.69	12.48
Gain for H 109	+37.35	+0.49	+5.25

H 8969. Pahala (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.

H 8973. Kahuku (No harvesting data), reports good growth.
Pioneer (No harvesting data),reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8973	113.03	9.67	11.69
Gain for H 109	+32.74	+1.45	+6.04

H 8978. Kahuku (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8978	130.23	9.66	13.32
Gain for H 109	+15.54	+1.44	+4.41

H 8982. Waiakea (No harvesting data), reports good growth.
H 8984. Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
H 8988. Oahu Sugar (No harvesting data), reports good growth.
Pioneer (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa (No harvesting data), reports good growth.
H 8993. Pahala (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Kahukû (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8993	91.98	8.89	10.35
Gain for H 109	+53.79	+0.67	+7.38

H 8994. Pioneer (No harvesting data), reports good growth.
Kahuku (No harvesting data), reports good growth.
Waialua (No harvesting data), reports good growth.
Waipio (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
H 89102. Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	159.29	8.10	19.67
H 89102	116.69	8.69	13.43
Gain for H 109	+42.60	+0.59	+6.24

H 89164. Ewa (No harvesting data), reports good growth.
H 89205. Ewa (No harvesting data), reports good growth.
H 89258. Ewa (No harvesting data), reports good growth.
H 89282. Ewa (No harvesting data), reports good growth.

1918 Seedlings Selected by Dr. Lyon

H 8139. Pioneer, no harvesting data, reports good growth.
H 86441. Pioneer, no harvesting data, reports good growth.
H 86441. Ewa, no harvesting data, reports good growth.
H 86465. Ewa, no harvesting data, reports good growth.
H 86465. Pahala, no harvesting data, reports good growth.
H 86484. Ewa, no harvesting data, reports good growth.
H 86484. Pahala, no harvesting data, reports good growth.

Ewa Seedlings—

Harvesting data on three of the Ewa seedlings propagated in 1915-16 gave the following yields:

Variety	Cane	Q. R.	Sugar
H 109	147.64	9.39	15.72
Ewa 371	132.71	9.18	14.46
Gain for H 109	+14.93	—0.21	+1.26
H 109	112.66	8.04	13.41
Ewa 383	107.85	8.42	13.38
Gain for H 109	+4.81	+0.38	+0.03
H 109	158.09	10.41	15.19
Ewa 387	123.64	8.82	14.02
Gain for H 109	+34.45	—1.59	+1.17

1919—1920 H. S. P. A. Seedlings—

Seedlings of the 1919 and 1920 propagations are just beginning to be spread to large enough areas so that estimates can be made of their worth.

Uba Hybrid No. 1 is being watched with interest.

H 9923 is attracting attention on account of its rapid growth.

The Badila seedlings are below standard.

Sugar Losses in Cane Damaged by Rats and Beetle Borer*

By Raymond Elliott.

The brown rat (Rattus norvegicus), and cane borer (Rhabdocnemis obscura, Boisd.) are the two major pests of cane in the Hamakua district. The damage done amounts to thousands of dollars annually.

The rat is being somewhat controlled by artificial methods, i. e., poisons, traps, etc. The cane borer has its natural enemy, the Tachinid fly (Ceremasia sphenophari).

Mr. Pemberton, of the H. S. P. A. Experiment Station, has been examining borer-injured cane to determine the efficiency of the borer parasite at Paauhau. His results on that particular phase of control will be published later.

The object of the writer, in conducting the following experiments, is to show in dollars and cents just what this loss amounts to.

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924

There were fifty experiments, twenty-six rat-eaten cane and twenty-four cane borer injury, harvested over a period of four months (February to May, 1924, inclusive), from five irrigated fields. Each experiment represents approximately ten acres.

Thirty feet of a cane row were taken at different parts of the field. The row was stripped, it was then cut and the stalks counted. Each stick was examined for damage done by the cane borer or rat, depending upon whether it was a rat or cane borer experiment, and tabulated accordingly.

The cane was then brought to the mill, weighed and divided into two separate piles and labeled piles Nos. 1 and 2. Pile No. 1 was then divided into seven equal parts and analyses made. This bundle will serve as a control over that part which is actually infested by the borer or damaged by the rat.

In pile No. 2, all sound cane and damaged cane were segregated. The sound cane was weighed and divided into seven equal parts, analyzed and designated as 2A.

The damaged cane is gone over very thoroughly and that part which is damaged is cut out. If the stalk still shows a red discoloration and gives off a sour odor it is still cut away until the discolored parts and odor disappear. The sound parts are weighed, analyzed and designated as 2B.

The damaged part is weighed, analyzed and designated as 2C.

A summary of the results is as follows:

TABLE I.

CANE BORER DAMAGE

No. of Experiments	Variety	Per cent Sticks With Cane Borer
3	H 20	55.56
11	Y. C.	30.54
3	D 1135 and Y. C.	22.58
2	H 109	21.43
5	D 1135	11.32
24		True Average....27.17

RAT DAMAGE

No. of Experiments	Variety	Per cent
2	H 20	50.24
6	D 1135	36.07
16	Y. C.	29.07
1	H 109	23.77
1	D 1135 and Y. C.	22.58
26		True Average....32.92

The analyses of the cane borer and rat-eaten cane experiments follow:

TABLE II.

	Bundle No. 1								Bundle No. 2							
	1				2A				2B				2C			
	Control (sound and unsound cane)				Sound Cane				Sound Cane after damaged parts had been cut out				Damaged parts			
True Averages	Brix	Pol'n	Pur.	Q. R.	Brix	Pol'n	Pur.	Q. R.	Brix	Pol'n	Pur.	Q. R.	Brix	Pol'n	Pur.	Q. R.
Cane Borer Experiments	18.82	16.79	89.21	7.90	19.35	17.44	90.13	7.55	19.08	16.97	88.94	7.83	14.01	9.83	70.16	16.67
Rat-Eaten Cane Exps....	18.28	16.15	88.35	8.27	18.87	16.71	88.55	7.98	17.92	15.77	88.00	8.49	13.14	9.13	69.48	18.15

N. B. Wt. of Bundle 1, Wt. of Bundle 2 = Total Wt. Wts. 2A, 2C = Wt. Bundle 2.

The figures that we are most interested in are those of 2A and 2C. If the cane was all damaged as in 2C it would take the above amounts, as indicated, to make a ton of sugar. However, when the weights are really known, it is much larger than a person would expect. The actual weights of damaged cane are 7.47 lbs., 7.81 lbs. per 100 lbs. of cane by the rat and cane borer respectively.

Taking the stalks and cutting out that portion which is damaged, we have 30.83 and 31.78 lbs. per 100 lbs. of cane respectively.

Table III.

Per cent Rat Eaten Cane and Losses Calculated to Dollars and Cents, Taking Sugar at $0.07 per lb.

RAT-EATEN CANE LOSSES

	F. 2	F. 9	F. 15½	F. 14A	F. 7	True Ave.
Per cent total sticks rat eaten	10.42	14.51	36.07	48.21	54.00	32.92
Per cent loss in sugar per acre	1.305	1.357	4.366	6.594	16.430	5.861
Loss in dollars and cents per acre	9.912	14.028	43.400	61.810	135.128	51.884
Loss in dollars and cents per 1 per cent rat-eaten cane per acre	.951	.967	1.203	1.282	2.502	1.576

Table IV.

Per cent Infestation and Losses Calculated to Dollars and Cents, Taking Sugar at $0.07 per lb.

CANE BORER LOSSES

	F. 15½	F. 9	F. 2	F. 14A	F. 7	True Ave.
Per cent total sticks with cane borer	8.43	18.72	24.30	29.88	53.13	27.17
Per cent loss in sugar per acre	.394	1.460	.737	3.193	15.212	4.581
Loss in dollars and cents per acre	1.876	13.622	5.950	31.038	157.822	42.308
Loss in dollars and cents per 1 per cent infestation per acre	.223	.728	.245	1.038	2.970	1.557

Discussion of Results.

Table I, the number of stalks damaged, expressed as a percentage, shows that the variety H 20 is the most susceptible to damage by both enemies. The areas planted to H 20 at Paauhau are very small and are more in the nature of an experiment in the different fields. The number of experiments harvested are given opposite each variety and are self-explanatory.

Turning to the figures in Table II, the reader should bear in mind that the figures as given in 2A are the quality ratios of sound cane that is not damaged by either of the two above-mentioned pests; while in 2B are the stalks after having the damaged part cut out; 2C is that part that is actually damaged and is one of the factors for requiring more cane to make a ton of sugar, and incidentally giving a juice of somewhat lower purity.

The difference in quality ratios of 1 and 2A are indicative of the amounts to make a ton of sugar where you have damaged cane mixed with the sound cane and sound cane alone.

In Tables III and IV are given the percentages and losses by the rat and cane borer, field by field, with a true average summary.

In 1923, the writer did not conduct any experiments re the damage done by rats, experiments being confined to that of the cane borer.

The percentage of stalks with cane borer in 1923 approximates that of 1924 very closely, namely, 26.48 as against 27.17.

If we exclude the experiments of F7, the loss in dollars and cents for the cane borer and rat-eaten experiments are $0.56 and $1.10 per acre per one per cent infestation respectively.

The loss in the 1923 experiments for cane borer was $0.655 per one per cent of infestation per acre.

It should be noted that in the experiments on rat-eaten cane the greater the per cent stalks of cane damaged, the greater the loss in dollars and cents per one per cent rat-eaten cane per acre.

In the cane borer experiments, that is in most but not all cases, the greater the borer infestation, the greater the losses per one per cent infestation per acre.

Annual Synopsis of Mill Data, 1924

By W. R. McAllep

Data in this Synopsis, represent all sugar produced by plantations in the Association from September 30, 1923, to September 30, 1924. Data are included for portions of the 1923 crop of three factories that had not finished grinding on the former date. Five factories had not finished grinding in time to submit figures for all of the 1924 crop. The unfinished portions will be included in the next Synopsis. Figures including unfinished portions of the 1923, and figures that do not represent the whole of the 1924 crop are so designated in the first of the large tables.

The form in which data are presented is much the same as in the last few seasons. A number of tables give detailed information on quality of cane, milling, boiling house work, etc. Operating data and averages for the last ten years are in the first of the three large tables. The second large table contains mill settlings, etc., and the third, surface and juice grooving. When not otherwise noted, factories are listed according to the average size of the crop for the preceding five seasons.

Attention was called in last year's Synopsis to peculiarities in control figures for the Petree process. Many of these figures are not directly comparable with corresponding data for factories that do not return settlings to the mill. Averages for the total crop as compiled in these Synopses are materially affected in some particulars. The writer would refer to last year's Synopsis for further details. A third factory has now installed this process and the other two have had proportionately larger crops, increasing the percentage of sugar produced by this process from 12 per cent in 1923 to slightly under 16 per cent this year. Last year averages were influenced by these figures to the extent that valid comparisons with the work of previous years, on the basis of true averages for all the factories, were rendered difficult and uncertain. This year the difficulty is accentuated.

Data as compiled in these Synopses serve a useful purpose in classifying factories according to the quality of the work. In the writer's opinion, however, comparisons of one season's work with another on the basis of averages for the entire crop, particularly when supplemented with analyses of results at individual factories serve a much more useful purpose. In several respects these comparisons afford more definite and reliable information than can be obtained in any other way. They show to what extent results indicated by experimental work are secured in practice. They reflect the effect of changes in conditions and operating methods and show in true perspective the general trend of factory operations. The difficulty in making close, valid comparisons with previous seasons in extraction, recovery and other averages affected by the Petree process, detracts materially from the value of these Synopses.

Table 3 containing averages for the last three years for all factories that do not now use the Petree process, overcomes the difficulty for these three seasons. By taking into consideration differences between 1922 averages in Table 3 and corresponding 1922 averages for all factories, somewhat better comparisons can be made with the work of years previous to 1922 than can be made on the basis of averages in the large table, but the comparisons are still unsatisfactory.

TABLE NO. 1

VARIETIES OF CANE

	H 109	Y. C.	D 1135	Lahaina	Striped Mexican	Yellow Tip	Striped Tip	Rose Bamboo	Other Varieties
H. C. & S. Co.	77	..	15	7	1	..	..	..	..
Oahu	70	..	15	5	..	..	..	..	10
Ewa	100	..	..	..	..	..	..	..	..
Waialua	37	10	25	7	..	..	..	..	21
Pioneer	58	..	3	4	31	..	..	..	4
Olaa	..	87	13	..	..	..	..	..	..
Haw. Sug.	53	1	32	..	..	..	..	..	14
Maui Agr.	61	2	1	14	9	..	..	13	..
Onomea	..	78	..	..	..	22	..	..	..
Lihue	18	79	1	..	..	..	..	..	2
Haw. Agr.	..	53	10	..	4	..	..	..	33
Hakalau	..	93	..	..	..	7	..	..	..
Honolulu	75	19	5	1	..	..	..	..	..
Kekaha	19	..	16	62	..	..	..	..	3
Hilo	..	95	5	..	..	..	..	..	..
Wailuku	62	1	2	15	20	..	..	..	..
McBryde	54	36	10	..	..	..	..	..	..
Makee	20	78	..	..	..	..	..	..	2
Honokaa	7	19	73	..	..	..	..	..	1
Laupahoehoe	..	42	12	..	..	42	3	..	1
Pepeekeo	..	93	1	..	..	6	..	..	..
Hamakua	..	34	50	..	..	3	1	..	12*
Kahuku	49	46	..	5	..	..	..	..	..
Paauhau	6	42	45	..	..	6	..	..	1
Honomu	..	99	..	..	..	..	..	..	1
Koloa	14	77	5	..	..	..	..	..	4
Waiakea	..	98	1	..	..	1	..	..	..
Hutchinson	..	39	..	..	..	..	1	59	1
Hawi	28	9	19	..	4	3	37	..	..
Waianae	100	..	..	..	..	..	..	..	..
Kaiwiki	..	48	14	..	..	2	21	..	15*
Kohala	..	22	40	..	..	11	23	..	4
Kilauea	8	59	2	..	..	..	..	..	31†
Kaeleku	..	100	..	..	..	..	..	..	..
Waimanalo	76	23	1	..	..	..	..	..	..
Halawa	..	40	15	..	..	..	45	..	..
Union Mill	..	14	8	..	..	..	77	..	1
Waimea	40	1	2	56	..	..	..	..	1
Olowalu	73	..	..	5	22	..	..	..	..
Niulii	..	55	14	..	..	15	16	..	..
True Average 1924.	38.1	32.6	12.0	4.4	2.5	2.3	2.0	1.4	4.7
" " 1923.	30.7	36.3	11.2	8.4	3.1	1.2	1.6	1.5	6.0
" " 1922.	21.1	40.3	12.2	12.0	2.8	2.7	1.6	1.6	5.7
" " 1921.	15.0	45.1	11.0	17.4	3.0	1.2	1.8	1.0	4.5
" " 1920.	9.1	42.7	10.0	26.7	2.5	1.4	2.1	0.8	4.7
" " 1919.	6.8	46.4	7.2	29.1	1.8	0.3	2.6	2.1	3.7
" " 1918.	4.0	42.9	7.5	37.9	0.6	0.5	1.5	1.1	4.0

* Principally D 117.

† Principally Badila

TABLE NO. 2

COMPOSITION OF CANE BY ISLANDS

	Hawaii	Maui	Oahu	Kauai	Whole Group
1915					
Polarization	12.61	15.23	14.29	14.09	13.77
Percent Fiber	13.00	11.44	12.77	12.46	12.51
Purity 1st Expressed Juice	87.86	90.48	87.27	86.99	88.24
Quality Ratio	.....	.....	.....	.....	8.03
1916					
Polarization	12.54	14.62	13.74	13.26	13.45
Percent Fiber	13.22	12.22	12.51	12.86	12.74
Purity 1st Expressed Juice	87.56	89.41	87.15	86.26	87.70
Quality Ratio	.....	.....	.....	.....	8.22
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Percent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Expressed Juice	88.11	90.40	86.77	86.70	88.02
Quality Ratio	8.21	7.03	8.20	8.27	7.95
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Percent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Expressed Juice	87.27	88.62	86.93	85.88	87.18
Quality Ratio	9.27	7.73	8.27	8.60	8.47
1919					
Polarization	12.74	15.12	14.24	13.52	13.74
Percent Fiber	13.07	11.74	12.14	12.61	12.49
Purity 1st Expressed Juice	87.54	88.81	87.00	85.82	87.34
Quality Ratio	8.66	7.25	7.81	8.20	8.05
1920					
Polarization	12.86	15.29	13.75	13.07	13.64
Percent Fiber	13.36	11.39	12.65	12.72	12.64
Purity 1st Expressed Juice	87.87	88.94	85.40	86.52	87.24
Quality Ratio	8.45	7.08	8.07	8.28	8.00
1921					
Polarization	12.25	14.67	13.72	12.67	13.12
Percent Fiber	13.28	11.82	12.40	13.28	12.80
Purity 1st Expressed Juice	87.18	87.37	85.46	84.07	86.22
Quality Ratio	8.98	7.51	8.11	8.76	8.41
1922					
Polarization	12.07	13.95	13.61	13.03	12.97
Percent Fiber	13.16	12.38	12.88	13.22	12.95
Purity 1st Expressed Juice	87.17	87.88	86.18	85.80	86.84
Quality Ratio	9.19	7.75	8.04	8.36	8.45
1923					
Polarization	12.09	13.61	12.99	12.94	12.78
Percent Fiber	13.14	12.01	12.86	12.99	12.82
Purity 1st Expressed Juice	87.61	88.65	85.52	86.58	87.05
Quality Ratio	9.12	7.91	8.50	8.42	8.57
1924					
Polarization	12.44	14.34	13.48	13.34	13.26
Percent Fiber	12.99	12.16	12.72	12.94	12.74
Purity 1st Expressed Juice	87.98	89.19	87.02	87.31	87.86
Quality Ratio	8.86	7.58	8.16	8.12	8.25

Varieties of Cane

Varieties ground to the extent of 1 per cent or more of the total crop are included in Table 1. D 117 no longer appears, as the tonnage of this variety has dropped to less than 1 per cent of the total crop. Yellow and Striped Tip are tabulated in separate columns instead of together as in previous years. This table shows the proportion of the major varieties ground at each factory. Averages for the previous six years are included.

For the first time in many years, Yellow Caledonia has been displaced as the leading variety in tonnage ground. The proportion of H 109 exceeds Yellow Caledonia this year to approximately the same extent that Caledonia exceeded H 109 in 1923. The proportion of Lahaina is but little more than a half of what it was a year ago. This once important variety now amounts to but 4.4 per cent of the crop. It is interesting to note that the proportions of H 109 and Lahaina in 1918 and 1924 are almost exactly reversed. Taking into consideration the biennial nature of the crop, D 1135 and Striped Mexican are about holding their own. The proportion of the Tip canes is the same as in 1922. The proportion of Rose Bamboo has been steadily decreasing during the last three years.

Minor varieties making up 1 per cent or more of the crop of any one plantation were ground to the following extent:

Variety	Per Cent of Total Crop
H 146	.51
D 117	.49
Badila	.46
White Bamboo	.11
Uba	.03
Yellow Bamboo	.02
Total	1.62

H 227 and H 20 were in this classification last year. None of the former was reported this season. H 20 was ground to a slightly greater extent than Uba but did not make up 1 per cent of the crop at any plantation. Of the varieties listed above, H 146, D 117 and Yellow Bamboo have decreased considerably in comparison with last year. Badila has increased materially, the proportion last year being only .13 per cent. Uba appears in this classification for the first time.

Quality of Cane

Table 2 contains data on quality of cane by Islands and for the whole group for the past ten years. Quality ratios have been included this year to facilitate comparisons.

Last year the quality of the cane had improved slightly over that of the two previous seasons. This year a material further improvement has taken place. The quality ratio has decreased from 8.57 to 8.25. On Oahu the quality is the best since 1922, on Maui since 1921, on Hawaii since 1920 and on Kauai since 1919. The average quality is better than in any year since 1920. As is usually

TABLE NO. 3.

True Averages of All Factories Except Those Now Using the Petree Process.

	1922	1923	1924
Cane—			
Polarization	12.77	12.66	13.08
Fiber	13.03	12.91	12.82
Tons per ton sugar	8.76	8.68	8.40
Bagasse—			
Polarization	1.71	1.53	1.52
Moisture	41.31	41.29	41.26
Fiber	56.23	56.48	56.74
Polarization per cent cane	0.40	0.35	0.34
Polarization per cent polarization of cane	3.11	2.76	2.63
Milling loss	3.05	2.71	2.68
Weight per cent cane	23.16	22.84	22.59
First Expressed Juice—			
Brix	18.23	17.99	18.34
Polarization	15.79	15.61	16.07
Purity	86.58	86.77	87.61
"Java ratio"	80.9	81.1	81.4
Mixed Juice—			
Brix	13.26	13.11	13.37
Polarization	11.07	11.00	11.31
Purity	83.50	83.87	84.56
Weight per cent cane	111.65	111.95	112.66
Polarization per cent cane	12.38	12.31	12.74
Extraction	96.89	97.24	97.37
Extraction ratio	0.24	0.21	0.21
Last Expressed Juice—			
Polarization	1.96	1.73	1.84
Purity	68.66	68.48	71.73
Maceration per cent cane	34.99	34.79	35.30
Syrup—			
Brix	63.11	63.33	63.18
Purity	84.81	85.40	86.02
Increase in purity	1.31	1.53	1.46
Press Cake—			
Polarization	1.96	2.20	2.16
Weight per cent cane	2.49	2.45	2.45
Polarization per cent cane	0.05	0.05	0.05
Polarization per cent polarization of cane	0.38	0.43	0.40
Lime used per cent cane	0.081	0.085	0.086
Commercial Sugar—			
Polarization	96.88	96.88	97.20
Moisture	0.85	0.80	0.73
Weight per cent cane	11.41	11.53	11.91
Polarization per cent cane	11.06	11.17	11.58
Polarization per cent polarization of cane	86.94	88.37	88.76
Polarization per cent polarization of juice	89.69	90.86	91.16
Final Molasses—			
Weight per cent cane	3.14	2.96	2.83
Sucrose per cent cane	1.07	0.99	0.97
Sucrose per cent polarization of cane	8.33	7.79	7.45
Sucrose per cent polarization of juice	8.60	8.01	7.65
Gravity solids	87.94	88.54	89.08
Gravity purity	38.60	37.68	37.81
Undetermined Losses—			
Polarization per cent cane	0.21	0.11	0.14
Polarization per cent polarization of cane	1.28	0.65	0.76

the case, the cane is best on Maui and poorest on Hawaii. It is of practically the same quality on Oahu and Kauai, a slight difference of .04 in quality ratio being in favor of Kauai.

A most satisfactory development is improvement in juice purity. The average purity of the first expressed juice is better than in any year since 1917. This is also true of Maui and Hawaii. On Oahu the purity is better than in any year since 1916, while on Kauai it is necessary to go back to 1914 to find better first expressed juice purity. On the basis of first expressed juice purity, the Islands rank as follows: Maui, Hawaii, Kauai and Oahu.

The average fiber is lower than in the preceding three seasons. For a number of years there has been a consistent tendency toward lower fiber on Hawaii. The figure reported this year is lower than in any year since 1910. On Maui the tendency is toward higher fiber. With the exception of 1922, the fiber reported from Maui is the highest on record. On Oahu the fiber was lower than in the preceding two seasons and on Kauai, lower than in the preceding three.

Milling

An interesting feature of the milling work this year is the increased grinding rate. Average grinding rates for the last five years are in the following tabulation. This figure is the total tons of cane ground divided by the total hours grinding. Average tons pressure per linear foot of roller for the last three years are also included. Two-roller crushers have not been included in the calculation:

	Tons Cane per Hour	Tons Pressure per Linear Foot of Roller
1920	39.34	...
1921	36.58	...
1922	39.93	65.2
1923	42.03	66.2
1924	43.63	66.9

Grinding rates have increased each year since 1921, the total increase amounting to 19 per cent. The increase over last year is 1.6 tons per hour. The increase has been quite general, but three factories reporting decreases of one ton or more per hour. Pressure per foot of roller has also steadily increased in the years for which figures are available.

Water added per cent cane has decreased from 35.12 to 34.90. The water actually applied per hour has increased slightly (3 per cent), due to the increased grinding rate. With the single exception of 1922, water added per cent cane has been lower than in any year since 1914. At factories that do not use the Petree process, maceration increased from 34.79 to 35.3 per cent.

Comparison of averages for all factories with corresponding 1923 figures discloses the following: Milling loss, or parts of sugar lost in bagasse per hundred parts of fiber in bagasse has increased from 2.76 to 2.78, while extraction ratio, or the ratio of per cent unextracted sucrose to fiber in cane, has decreased from .22 to .21. Bagasse increased .01 in polarization and .02 in moisture. With

higher polarization and moisture, lower fiber in bagasse might be expected. On the contrary the fiber has increased .01. This is due to an increase in residual juice purity, that is, a reduction in the soluble impurities in the juice remaining in the bagasse. Taking all these factors into consideration, the quality of the milling work very closely approximates that of last season, notwithstanding the higher grinding rate and decreased maceration.

Due to higher polarization and lower fiber in cane, the extraction is .10 higher than last year. Figures for the Petree process have increased the average figure by possibly .03 above what it should be. Deducting this from the average gives a figure identical with that of 1919, between .10 and .15 lower than in 1920 and 1921, and higher than in other years.

At factories that are not using the Petree process (Table 3), in comparison with last year, bagasse polarization has decreased 0.01 and bagasse moisture .03, while bagasse fiber has increased .26. Milling loss has decreased .03. Extraction ratio has decreased from .214 to .205, though the decrease is not apparent in the table where the figures are carried to two decimal places only. Extraction has increased .13. At these factories the milling work is better than in 1923 or 1922. As previously pointed out comparisons with years previous to 1922 are unsatisfactory, but as nearly as the figures can be interpreted, milling work at these factories is as good as in any previous season. It is quite probable that except for the Petree process, milling work as a whole would have been equal to that of any previous year, notwithstanding the increased grinding rate.

The difference in purity between first expressed juice and mixed juice, as shown by figures in Table 3, has increased from 2.90 to 3.05. While a number of factors can influence this difference, the amount of field trash and deterioration in the mill are probably the most important. So far as this difference can be accepted as an indication of the amount of field trash and deterioration the indications are that conditions with respect to one or both of these factors have been less favorable than last year. A peculiarity of the data this year is that although the purity difference between first expressed and mixed juice purity is greater than last year the difference between first expressed and last expressed juice purity has decreased from 18.74 to 16.24.

No factory has quite equalled the previous record of 1.09 in milling loss established by Onomea and Hakalau last year, nor has any factory equalled the record for extraction (99.07) established by Hawaiian Commercial and Sugar Company in 1921. Waimanalo has equalled the previous low mark in extraction ratio made by Hawaiian Commercial and Sugar Company in 1921.

The principal changes in milling machinery have been: increasing the milling plant at Kekaha to a fifteen-roller mill and crusher by installing two three-roller units, and installing a three-roller in place of a two-roller crusher at Honomu. The three-roller crusher and nine-roller mill at Waimanalo may be considered a new installation so far as Synopsis figures are concerned, for though operated for two seasons, the previous year's figures were not in the Synopsis.

Reference to Table 4 in which the factories are listed in the order of the size of the milling loss shows that improved work has been secured from these installations. Waimanalo is in second place with 98.87 extraction and 1.12 milling loss. Milling data have not been reported previously from this factory, but un-

doubtedly it was close to, if not at the foot of the list. Kekaha has advanced from thirty-fourth place last year to fifth this year with 1.72 milling loss and 98.48 extraction. Honomu has advanced from seventeenth to sixth place with 1.77 milling loss and 98.27 extraction.

Seven factories report milling losses under 2.0 against five in 1923 and four in 1922. Nine report over 98.0 extraction against five in each of the two preceding years. This equals the previous record for number of factories under 2.0 in milling loss made in 1920. The same number of factories (9), reported better than 98.0 extraction both in 1920 and 1921.

On the basis of milling loss Onomea is first, with Waimanalo second, and Hakalau third. There is little difference between these three leading factories, the figures for milling loss being respectively 1.11, 1.12 and 1.14. Indeed, which of the three is in first place depends on whether milling loss, extraction ratio or extraction is the basis of comparison.

Comparisons of Table 4 with corresponding tables in the previous Synopsis show many changes in relative rank. In addition to the previously mentioned improvements in relative standing due to the installation of new machinery, the following factories have improved their standing to the extent of 5 points or more: Honolulu (33-23), McBryde (25-18), Kahuku (22-16), Ewa (18-13) and Wailuku (13-8). Factories that have dropped in relative rank to the extent of 5 points or more are: Waimea (15-28), Maui Agricultural (19-31), Oahu (10-21), Waialua (21-30), Lihue (7-14), Makee (8-15), Kilauêa (12-19), Hamakua (6-12), Hawaiian Agricultural (14-20), Waiakea (31-37) and Laupahoehoe (24-29).

The fact that three of the first nine mills in Table 4 are three-roller crushers and nine-roller mills, while one is in second place, draws attention to the efficient work secured from modern three-roller crushers. An extraction of 75 per cent of the total juice is not particularly high for a three-roller crusher working under reasonably favorable conditions, while securing 50 per cent of the total juice is excellent work with two-roller equipment. Eight installations are classed in this Synopsis as three-roller crushers. Two of these are not properly grooved and can hardly be considered modern three-roller crushers. At a third installation, Petreé process settlings are returned to the mill. The remaining five three-roller crusher installations are all in the first half of Table 4. In each case the three-roller crusher is a material factor in the results secured. There is little doubt that comparisons of two and three-roller crushers, taking into consideration fixed charges, operating expenses and the results secured, are considerably in favor of the three-roller type. There are a number of factories without a crusher where substituting properly grooved crusher rollers for the rollers now in the first mill, would bring about a material improvement in the work.

It might also be noted that the Waimanalo factory is equipped with Meinecke chutes. The excellent milling work at this factory should dispose of any doubts that may have existed as to the possibility of securing excellent results with this type of intermediate conveyor.

TABLE NO. 4—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1. Onomea	1.11	0.09	98.89	2RC60,S54,12RM66
2. Waimanalo	1.12	0.08	98.87	K,3RC54,9RM54
3. Hakalau	1.14	0.09	98.90	2RC60,12RM9-60,3-66
4. Hilo	1.22	0.10	98.60	K,2RC60,12RM66
5. Kekaha	1.72	0.12	98.48	2RC54,15RM60
6. Honomu	1.77	0.14	98.27	3RC60,9RM60
7. Pepeekeo	1.84	0.15	98.21	2RC54,9RM60
8. Wailuku	2.04	0.15	98.07	K,2RC72,12RM78
9. Olowalu	2.05	0.16	97.99	K,3RC48,9RM48
10. Paauhau	2.27	0.19	97.51	2RC60,12RM66
11. Pioneer	2.32	0.16	98.06	K,2RC72,S72,15RM72
12. Hamakua	2.32	0.19	97.36	K,2RC60,12RM60
13. Ewa	2.36	0.18	97.73	K(2),2RC78,18RM78
14. Lihue	2.36	0.19	97.62	K,2RC78,S72,12RM78
15. Makee	2.56	0.21	97.16	2RC72,S72,9RM72
16. Kahuku	2.65	0.21	96.63	2RC60,S54,9RM72
17. Haw. Sug.	2.69	0.18	97.81	K,2RC72,S72,12RM78
18. McBryde	2.81	0.20	97.11	K,2RC72,S72,9RM84
19. Kilauea	2.82	0.23	96.77	K,S,3RC60,9RM60
20. Haw. Agr.	2.88	0.24	96.86	3RC60,12RM66
21. Oahu	2.89	0.20	97.51	K(2),2RC78(2),S72(2),12RM78(2)
22. Koloa	2.98	0.23	96.83	K,2RC60,12RM66
23. Honolulu	3.07	0.22	97.45	K(2),S54,2RC78,9RM78
24. Hutchinson	3.07	0.26	96.88	2RC60,9RM60
25. Waianae	3.10	0.23	96.88	K(2),12RM60
26. Olaa	3.16	0.24	96.89	K,S72,12RM78
27. Honokaa	3.18	0.28	96.49	K(2),2RC66,12RM66
28. Waimea	3.26	0.24	97.07	2RC48,12RM42
29. Laupahoehoe	3.27	0.25	96.72	K,2RC60,9RM60
30. Waialua	3.36	0.25	96.71	K(2),2RC78,12RM78
31. Maui Agr.	3.41	0.23	97.33	K(2),3RC66,18RM66
32. Kaiwiki	3.44	0.27	96.35	K,2RC60,9RM60
33. Kohala	3.55	0.28	96.39	K(2),3RC60,9RM60
34. H. C. & S. Co.	3.72	0.26	96.92	K(4),2RC78(2),S72(2),12RM78(2)
35. Kaeleku	4.15	0.35	95.04	K,2RC54,9RM60
36. Hawi	4.34	0.32	95.90	K(2),3RC48,12RM3-48,9-54
37. Waiakea	4.34	0.33	95.27	K,2RC60,9RM60
38. Halawa	5.77	0.48	93.35	K,2RC60,6RM50
39. Union Mill	6.59	0.52	92.87	K,9RM60
40. Niulii	7.53	0.63	91.37	K,9RM54

Extra Fuel

Available data are not sufficiently complete to attempt an at all complete analysis of figures for extra fuel. Fifteen factories, the same number as last year, report the use of extra fuel in greater amounts than should be required for starting up or be occasioned by unexpected delays.

Two factories, Pioneer and Hawaiian Commercial and Sugar Company, accumulated large surpluses of bagasse. The latter, a Petree process factory, accumulated a very large surplus. Maui Agricultural Company, another Petree process factory, made a large reduction in the amount of extra fuel burned in comparison with last year. Waialua and Oahu also report material reductions in the extra fuel requirement.

The writer would repeat the comment made in previous Synopses: that under Hawaiian conditions, with a sufficient supply of cane to grind at a reasonable capacity and with suitable equipment and proper operation, the bagasse, particularly when supplemented with molasses, should furnish sufficient fuel to maintain a high quality of work. Frequently material improvements in fuel conditions can be secured through comparatively minor changes in equipment and operating practice. In some cases however, installations are faulty to the extent that a satisfactory solution of the fuel problem is an extensive undertaking.

Chemical Control and Sucrose Balances

The number of factories reporting the more reliable sucrose figures has increased fairly consistently from year to year. Twenty-five factories have reported sucrose figures, an increase of two over last year. One consideration rendering sucrose figures particularly desirable is the more accurate figure for undetermined loss. On a polarization basis this is from .5 to 1.0 per cent lower than it should be; a factor frequently lost sight of when considering operating data.

Gravity solids and sucrose balances for factories reporting sucrose figures are in Table 5. Where suspended solids in mixed juice has not been reported, it has been estimated at .25 per cent in calculating these balances.

Apparent boiling house recoveries are in Table 6. These are based on polarization. It is necessary in making the calculations to estimate gravity purities from the apparent purities. The factors indicated in the footnote accompanying the table, which are approximately the average differences between apparent and gravity purities for factories reporting both, are used for this purpose. Plus or minus one per cent in the figure for recovery on available covers the probable error due to estimating gravity purities in this way. True boiling house recoveries on a sucrose basis, for factories reporting necessary data, are in Table 7. Tables 6 and 7 are to a large extent a check on the accuracy of chemical control, though low figures may also indicate losses in addition to the losses reported in press cake and molasses. These calculations have been very useful for disclosing inaccuracies in estimating the amount of juice entering the boiling house, which were common when the control was based largely on juice measurements. Now that all but four factories weigh the mixed juice, serious errors in estimat-

TABLE NO. 5

GRAVITY SOLIDS AND SUCROSE BALANCES

Factory	Gravity Solids per 100 Gravity Solids in Mixed Juice				Sucrose per 100 Sucrose in Mixed Juice			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	1.5	83.3	14.8	0.4	0.3	93.0	6.5	0.2
Oahu	3.0	79.0	16.4	1.6	0.2	91.8	7.4	0.6
Ewa	6.5	74.4	16.4	2.7	0.5	90.2	7.1	2.2
Waialua	6.0	74.6	16.0	3.4	0.6	89.9	7.6	1.9
Pioneer	3.0	79.4	15.8	1.8	0.2	91.7	6.7	1.4
Haw. Sug.	4.1	81.3	14.0	0.6	0.9	93.1	5.9	0.1
Maui Agr.	0	82.9	....	17.1	0	92.0	....	8.0
Onomea	6.1	77.3	15.1	1.5	0.1	91.7	6.9	1.3
Haw. Agr.	3.7	77.8	17.2	1.3	0.2	88.6	7.9	3.3
Hakalau	3.4	79.1	15.4	2.1	0.1	92.8	6.6	0.5
Hilo	4.6	76.6	17.0	1.8	0.4	91.4	7.9	0.3
Wailuku	1.9	80.8	15.7	1.6	0.4	91.6	7.0	1.0
McBryde	4.9	77.5	17.2	0.4	0.3	91.0	7.8	0.9
Makee	2.3	75.0	19.5	3.2	0.3	88.8	8.8	2.1
Honokaa	5.6	74.2	18.2	2.0	0.4	90.2	8.5	0.9
Laupahoehoe	4.1	78.4	14.2	3.3	0.1	91.0	6.6	2.3
Pepeekeo	3.2	78.9	14.5	3.4	0.1	92.0	5.9	2.0
Hamakua	0	78.1	20.4	1.5	0	88.5	10.0	1.5
Paauhau	5.5	75.3	18.4	0.8	0.2	90.3	8.3	1.2
Honomu	5.2	77.2	16.5	1.1	0.3	91.9	7.0	0.8
Waiakea	4.1	78.1	16.0	1.8	0.5	90.7	7.7	1.1
Hutchinson	4.7	75.0	17.8	2.5	0.4	89.0	9.1	1.5
Kilauea	4.7	72.2	18.9	4.2	1.0	88.0	8.8	2.2
Waimanalo	6.3	73.6	17.4	2.7	0.8	88.9	8.6	1.7
Union Mill	5.4	76.0	17.4	1.2	1.4	89.2	8.7	0.7

ing the amount of juice entering the boiling house are not frequent. Also with the general improvement in the quality of the laboratory work there is little doubt but that syrup, sugar and molasses purities are more accurately determined than in former years. In the last two or three years there has been a material change in clarification practice, resulting in smaller losses through inversion because of more alkaline juices. With this change, an increased number of factories report over 100 per cent recovery on the calculated available. Among these are factories at which there is reason to believe that juice weights, and syrup, sugar and molasses purities are determined with a high degree of accuracy. Until the last two or three years we have been inclined to accept the calculated available as the maximum obtainable under the given purity conditions, particularly with calculations on a sucrose basis. Critical examination of our control methods indicates the following small discrepancies:

1. Solids in the sugar are determined by drying. This gives total solids. The purity of the sugar as so determined is slightly higher than the gravity purity.

2. There is a plus error in the method for determining the gravity purity of final molasses due to the lead precipitate, amounting to between .5 and 1.0 per cent. This error has been corrected in the new methods adopted by the Association of Hawaiian Sugar Technologists.

3. Another factor causing a plus error in determining the gravity purity of the molasses is the relative concentration of non-sugars in the solutions in which the brix of the molasses and syrup is determined. Our methods specify approximately the density of the mixed juice for both determinations. At equal densities the non-sugar concentration is higher in the molasses and as a result the gravity solids determination is relatively low. The molasses would have to be analyzed at concentration between 2 and 2.5 Brix for the gravity solids determination to be strictly comparable with the gravity solids determination in the syrup. It is not practicable to use such a dilute solution when analyzing the molasses. The difficulty could be avoided by determining solids by drying, but this is also hardly practicable under present conditions.

4. Some volatilization of solids takes place during boiling operations.

Individually these discrepancies are not large. Unfortunately all are in the same direction, tending to make the calculated "available" smaller than it should be. Present information does not permit us to closely estimate the combined effect of these discrepancies. It seems probable, however, that 100 per cent of, or even slightly more than the calculated available, can be recovered in a well conducted factory. Notwithstanding the above discrepancies the calculations in Tables 6 and 7 are useful checks on the control, but it is necessary to bear in mind that the "available" as calculated is slightly less than the theoretically available.

Two factories have reported more than 101 per cent recovery on available, according to figures in Table 6. It may or may not be significant that these two factories were the two lowest in gravity purity of final molasses; a condition that would accentuate No. 3 of the factors mentioned above. Sucrose figures would have helped somewhat in deciding whether or not the high recoveries on available at these factories were due to errors in the control. In the absence of sucrose

TABLE NO. 6

APPARENT BOILING-HOUSE RECOVERY

Comparing percent available sucrose in the syrup (calculated by formula) with percent polarization actually obtained.

Factory	Available *	Obtained	Recovery on Available
H. C. & S. Co.	93.20	93.97	100.8
Oahu	91.79	92.02†	100.3
Ewa	92.03	91.49	99.4
Waialua	90.81	91.39	100.6
Pioneer	92.79	92.45	99.6
Olaa	92.10	92.66	100.6
Haw. Sug.	93.85	94.57	100.8
Maui Agr.	92.26	92.03†	99.8
Onomea	93.03	92.08	99.0
Lihue	90.96	92.37	101.6
Haw. Agr.	92.75	89.71	96.7
Hakalau	92.38	93.17	100.9
Kekaha	91.17	91.14	100.0
Hilo	91.29	91.74	100.5
Wailuku	92.50	92.53	100.0
McBryde	92.35	92.05	99.7
Makee	90.08	89.82	99.7
Honokaa	90.65	90.86	100.2
Laupahoehoe	92.43	91.26	98.7
Pepeekeo	93.17	92.41	99.2
Hamakua	90.07	89.03	98.8
Kahuku	90.76	91.87	101.2
Paauhau	91.80	90.70	98.8
Honomu	92.62	92.55	99.9
Koloa	88.90	87.61	98.5
Waiakea	91.90	91.60	99.7
Hutchinson	89.81	89.99	100.2
Hawi	92.89	89.17	96.0
Waianae	88.41	86.50	97.8
Kaiwiki	92.45	91.32	98.8
Kohala	91.69	91.02	99.3
Kilauea	89.89	89.28	99.3
Kaeleku	89.32	90.24	101.0
Waimanalo	90.11	90.13	100.0
Halawa	90.88	90.82	99.9
Union Mill	90.72	90.86	100.2
Waimea	90.99	85.09	93.5
Olowalu	89.29	83.65	93.7
Niulii	90.48	90.85	100.4

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. One factory did not report moisture in sugar or gravity purity of molasses. In this case 1% and 38 have been used.

† Sucrose

TABLE NO. 7

TRUE BOILING-HOUSE RECOVERY

Comparing percent sucrose available and recovered

Factory	Available	Obtained	% Recovery on Available
H. C. & S. Co.	93.35	93.28	99.9
Oahu	91.79	91.98	100.2
Ewa	92.17	90.65	98.4
Waialua	90.95	90.44	99.4
Pioneer	92.87	91.88	98.9
Haw. Sug.	93.73	93.95	100.2
Maui Agr.	92.26	92.00	99.7
Onomea	92.85	91.79	98.9
Haw. Agr.	93.28	88.78	95.2
Hakalau	92.33	92.90	100.6
Hilo	90.97	91.77	100.9
Wailuku	92.40	91.97	99.5
McBryde	92.42	91.27	98.8
Makee	90.13	89.07	98.8
Honokaa	90.57	90.56	100.0
Laupahoehoe	92.43	91.09	98.5
Pepeekeo	93.08	92.09	98.9
Hamakua	90.01	88.50	98.3
Paauhau	91.78	90.48	98.6
Honomu	92.63	92.18	99.5
Waiakea	91.62	91.16	99.5
Hutchinson	89.77	89.36	99.5
Kilauea	89.26	88.89	99.6
Waimanalo	90.17	89.62	99.4
Union Mill	90.71	90.47	99.7

TABLE NO. 8

PERCENT MOLASSES PRODUCED ON THEORETICAL

H. C. & S. Co.	97.2	Laupahoehoe	79.2
Oahu	91.3	Pepeekeo	81.0
Ewa	86.2	Hamakua	93.1
Waialua	83.3	Kahuku	87.7
Pioneer	90.7	Paauhau	95.2
Olaa	88.3	Honomu	93.9
Haw. Sug.	98.5	Koloa	78.9
Onomea	90.7	Waiakea	91.0
Lihue	84.5	Hutchinson	88.4
Haw. Agr.	91.8	Hawi	120.7
Hakalau	87.9	Kaiwiki	101.0
Kekaha	92.4	Kohala	86.4
Hilo	90.3	Kilauea	84.8
Wailuku	92.1	Kaeleku	77.1
McBryde	99.0	Waimanalo	88.1
Makee	86.1	Union Mill	93.2
Honokaa	89.6	Olowalu	79.8

figures, these factories have not been included in Table 9, following former practice of omitting factories with over 101 per cent recovery on available in Table 6.

Boiling House Work

Clarification: The increase in purity from mixed juice to syrup for the factories averaged in Table 3 is 1.46 against 1.53 last year, a difference of .07. On this basis, the clarification is not quite as satisfactory as last year. With the exception of last year, however, the increase is better than in any year since 1919. Better increases in purity were secured at but 13 out of 36 factories reporting data necessary for a comparison. No decreases in purity have been reported in the last three years, though previously some decreases were almost invariably reported.

The average figure for lime used in all factories has decreased from .087 to .086. The decrease is largely on account of reductions at two of the Petree process factories. At the other factories (Table 3), lime used has increased .001 per cent. Changes in the amount used at individual factories are with few exceptions, small.

Information on the reaction, or changes in the reaction at which the clarification is conducted is desirable for judging to what extent results indicated by experimental work are secured in practice. At present the chemical control does not include determining reactions. The only information available on this point is the figure for the amount of lime used. This figure at best, is not particularly satisfactory. Both available CaO and the amount of CaO required to bring different juices to the most desirable reaction vary greatly. However, it is probable that these two factors are sufficiently equalized in the yearly average for all factories, to render figures for lime used reasonably satisfactory were it not for a third factor: the proportion of lime used in the settlings. This does seriously interfere with estimating changes in the reaction at which the clarification was conducted from changes in the amount of lime used. To illustrate the effect of this factor, let us take two cases. In one the juice is clarified with the amount of lime giving the largest increase in purity and no lime is used in the settlings. In the second case, with the same juice, the same total amount of lime is used, but a considerable proportion of the lime is added to the settlings. In the second case, the lime in the hot, strongly alkaline settlings reacts with insoluble organic matter. This neutralizes a part of the lime and adds to the soluble impurities in the juice. A further loss of lime, so far as its effect on clarification is concerned, takes place in the strongly alkaline press cake. In the second case, the clarification will be less alkaline even though the alkaline press juice is returned to the mixed juice. The increase in purity will be smaller, not only because the alkalinity will be below the most favorable point, but also because of organic matter dissolved by the lime.

In the last few years comparatively few factories have reported lime used in juice and in settlings separately, so we cannot judge from figures in the Synopsis whether more or less lime is now being used in the settlings. The writer would strongly recommend reporting lime used in settlings separately, as was the general

practice a few years back, for with the attention now given to clarification, this information is quite important.

But few factories can lime the juice at all times to the point where the maximum increase in purity is secured on account of the increase in the volume of settlings. An average liming is below the optimum point and as there has been an increase, though a small one, in the amount of lime used, a larger rather than a smaller increase in purity from mixed juice to syrup might be expected. Analysis of figures for individual factories does not disclose why the larger increase has not been secured. As just pointed out, however, the figures are incomplete as that they do not show changes in lime used in the settlings. A material increase in the amount of lime so used would account for the smaller increase in purity, for in this case, notwithstanding the slightly greater amount of lime used, the clarification would actually be less alkaline. There are some indications that this may have been the case. Increased grinding rate has probably necessitated a reduction in the volume of settlings to keep within the capacity of the filter presses. A reduction in the volume of settlings under otherwise equal conditions means a less alkaline clarification. Also in the last year or two it has been necessary at many factories to increase the lime in the settlings in order to handle the increased volume resulting from alkaline clarification with available filtration equipment. It is not unreasonable to suppose that, operating at a higher capacity this year, this tendency has continued. The increase in undetermined loss from .65 to .76 is also to some extent an indication of a less alkaline clarification, for the benefit of the change in clarification practice has been as much in decreased undetermined losses due to reduced losses through inversion as to the additional increase in purity secured in clarification.

The above discussion of results obtained in clarification has necessarily been with reference to averages for factories that do not use the Petree process (Table 3). Comparisons of the decrease in purity from first expressed juice to syrup can be made on the basis of averages for all factories. This figure represents the combined effect of conditions during milling and during clarification. Figures for this purity difference for the last few years follow:

Year	Purity Difference First Expressed Juice to Syrup
1921	2.32
1922	1.88
1923	1.40
1924	1.54

Averages for this decrease in purity are available as far back as 1914. The 1923 figure 1.40, is the same as the previous minimum figures in the years 1914 and 1918. This year's decrease, 1.54, is .14 larger than last year. It is, however, smaller than in 6 of the preceding ten years. Responsibility for the larger decrease is probably about equally divided between clarification and conditions at the mill.

This year's syrup purity, 86.32, is higher than in any year since 1917. Had the decrease in purity from first expressed juice to syrup been as small as it was

last year, the syrup purity would have been 86.46, a figure higher than in any year since 1915.

Filter Presses: Filter press operation was slightly more satisfactory than in the previous year. The quantity of press cake, .45 per cent, remains the same. The polarization was reduced from 2.20 to 2.16, reducing the loss in press cake per cent polarization of cane from .43 to .40.

Evaporation: The brix of the syrup, 63.32, is slightly better than last year. While slightly lower than in 1922, it is better than in other years for which we have a record. The amount of water evaporated per unit of time is some 3 per cent higher than last year. Water evaporated per cent mixed juice, however, is slightly lower due to higher juice densities.

Commercial Sugar: The average polarization of the sugar has increased from 96.90 to 97.18. This polarization is higher than in other years for which we have a record, except 1910, 1911 and 1912. The highest polarization on record was 97.55 in 1911. The increase of .28 in sugar polarization, at this year's syrup and molasses purities, is equivalent to a reduction of approximately .15 in recovery. This does not mean that less "available" sucrose is recovered with higher polarizations. Rather, the reduction in recovery corresponds to the smaller amount of molasses retained in the commercial sugar.

Moisture in the sugar has decreased from .83 to .75 per cent, or slightly more than in proportion to the increase in polarization, reducing the deterioration factor from .268 to .265. The latter figure is still slightly high in comparison with .25 which we consider the safe point.

Low Grade: Higher juice purities have tended to decrease the duty required of low grade equipment, while higher polarizing sugar and higher grinding rate have tended to increase it. The net effect has been an increase of from 10 to 12 per cent in the duty imposed on this equipment. The final molasses purity has increased from 37.90, the previous low point reached a year ago, to 38.16. The increase is without doubt largely on account of the extra work required of the low grade centrifugals. Notwithstanding higher molasses purity the influence of higher syrup purity has been sufficient to reduce the loss of sucrose in molasses per cent polarization of cane from 7.58 to 7.41. These are the lowest figures for loss in molasses since 1919.

Kahuku reports an average gravity purity for the season of 33.09, establishing a new record for molasses purity. The previous record, 33.16, was made by the same factory last year.

Table 8, showing the percentage of molasses on the theoretical, is largely a check on the chemical control. As in previous Synopses, the theoretical has been assumed to be gravity solids in the syrup minus gravity solids in the sugar. On this basis the difference between 100 and the molasses produced on the theoretical represents the "apparent" loss of gravity solids. All of this, however, is not a real loss of solids, a part of the apparent loss being caused by one of the factors (No. 3), discussed on a previous page, which influence the calculations in Tables 6 and 7.

Applying this calculation to averages for the past four years gives the following figures:

Year	Molasses Produced on Theoretical
1921	87.2
1922	86.3
1923	90.9
1924	90.8
Average	88.8

This table was first included in the Synopsis to call attention to the wide discrepancy in molasses figures reported from some factories. Since then there has been a tendency toward more consistent figures. While definite information is not available as to the range which should include figures for molasses produced on the theoretical as calculated above, it would appear that five points on each side of the average in the above tabulation should be sufficiently wide to include nearly if not all the correct figures. Certainly some of the figures in Table 8 are far enough outside this range to strongly indicate errors in the control.

Recoveries

Boiling house recovery in comparison with last season has increased from 91.28 to 91.39, an improvement of .11. The average for this year is higher than in any year since 1911. The total recovery, or recovery per cent polarization of cane, 88.94, is .17 higher than the previous high point reached last year.

The improvement in comparison with 1923 is to be credited to the improvement in the quality of the cane rather than to better factory work. On the basis of last year's work, higher juice purity this year would have increased the total recovery .64. However, the increase in sugar polarization is equivalent to a reduction of .15 in recovery, so if the work had been of the same quality as in 1923 the total recovery should have increased .49, making it 89.26 instead of 88.94. These figures indicate that the work this year has been less efficient than in 1923 by the equivalent of .32 in recovery. This difference of .32 between the recovery secured and what should have been secured had the work been of the same quality as last year is made up as follows: Higher extraction and smaller losses in press cake are the equivalent of an increase of approximately .10 in recovery. The larger decrease in purity from first expressed juice to syrup, due both to conditions at the mill and clarification is equivalent to a reduction of .12. Higher molasses purity is equivalent to a further reduction of .10. The difference between the sum of these factors and .32 is .20, attributable to larger undetermined losses and the unavoidable small discrepancies in figures of this kind.

The following are Quality Ratios and Tons Cane Required to make a Ton of Sugar for the past few years. Comparisons of these values are most conveniently made on the basis of the reciprocal of Tons Cane per Ton of Sugar

multiplied by 100, thus converting Tons of Cane per Ton of Sugar into sugar recovered per cent cane:

Years	Quality Ratio	Tons Cane Required	Sugar % Cane Theoretical	Sugar % Cane Recovered	Recovered % Theoretical	Gain Over 1921
1921	8.414	8.605	11.885	11.621	97.78	...
1922	8.448	8.617	11.837	11.605	98.04	.36
1923	8.573	8.556	11.665	11.688	100.20	2.42
1924	8.248	8.256	12.124	12.112	99.90	2.12

In 1923 the cane required to make a ton of sugar was .017 of a ton less than the quality ratio while in 1924, .008 of a ton more than the quality ratio was required, a net increase of .025 of a ton, so on the quality ratio basis also, slightly poorer work than last year is indicated. 1924 percentage figures in the above tabulations are lower than the 1923 figures by .3 per cent. However, a half of the difference is accounted for by the higher sugar polarization. Therefore the comparison on a quality ratio basis, corrected for the increase in sugar polarization, indicates less efficient work than last year by some .15 per cent; a figure somewhat more favorable than the .32 per cent arrived at on the basis of recovery calculations.

To recapitulate, in comparison with last year the cane has been of much better quality and the mills have ground at an increased capacity. Milling work has been of approximately the same quality, though slightly higher extraction has been secured. The decrease in purity from first expressed juice to syrup is larger, indicating less favorable conditions at the mill and in clarification. Filter press work has improved slightly. The molasses was not reduced to as low a purity but due to higher juice purities the loss in molasses was reduced. For the same reason recovery figures are higher. The net result of all these factors has been work some .15 to .3 per cent less efficient than last year. Though the work is somewhat poorer than last year, by far the greater part of the improvement made a year ago, over the comparatively poor work of 1920, 1921 and 1922 has still been realized.

In Table 9 the factories are ranked according to the ratio of recovery secured to a calculated recovery. Calculated recoveries used as the standard for comparisons are based on syrup and sugar purities as reported, 100 per cent extraction, 37.5 molasses purity and no other losses. The same standard was used last season. One hundred per cent has no particular significance except in the column headed Milling, for as molasses can be reduced to considerably below 37.5 gravity purity, figures higher than 100 may appear in the second or even in the third column.

The basis of comparison used in Table 9 is not free from criticism, but since the standard has been changed to close to average molasses purity the discrepancies have been greatly reduced. These figures should be considered an approximate gauge of the quality of the factory work. If closer distinctions are desired it is necessary to supplement figures in Table 9 with other data reported from the factories in question, for so far as the writer is aware neither this nor any other method so far proposed gives an accurate numerical value for "factory efficiency."

The calculations in this Synopsis have been made by Mr. Alex. Brodie, assisted by others in the Sugar Technology Department.

TABLE NO. 9.

COMPARISON OF ACTUAL AND CALCULATED RECOVERIES.

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 37.5 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 6) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Hakalau	98.90	101.43	100.46
2	Honomu	98.27	100.37	98.91
3	Pepeekeo	98.21	100.23	98.58
4	Hilo	98.60	99.78	98.51
5	Pioneer	98.06	99.87	98.25
6	Haw. Sug.	97.81	100.22	98.22
7	Onomea	98.89	98.82	97.91
8	Ewa	97.73	99.78	97.87
9	Oahu	97.51	99.77	97.70
10	Wailuku	98.07	99.26	97.61
11	H. C. & S. Co.	96.92	100.21	97.47
12	Kekaha	98.48	98.37	97.13
13	Waimanalo	98.87	98.05	97.13
14	Olaa	96.89	99.72	96.97
15	Makee	97.16	99.32	96.82
16	Waialua	96.71	99.58	96.71
17	Honokaa	96.49	99.79	96.70
18	Paauhau	97.51	98.78	96.64
19	McBryde	97.11	99.18	96.61
20	Maui Agr.	97.33	98.38	96.19
21	Kilauea	96.77	98.36	95.52
22	Hutchinson	96.88	97.72	95.19
23	Laupahoehoe	96.72	98.13	95.16
24	Kohala	96.39	97.95	94.72
25	Hamakua	97.36	96.87	94.68
26	Kaeleku	95.04	99.12	94.58
27	Koloa	96.83	97.12	94.57
28	Waiakea	95.27	98.18	93.94
29	Kaiwiki	96.35	97.12	93.79
30	Haw. Agr.	96.86	95.90	93.11
31	Waianae	96.88	95.48	92.88
32	Halawa	93.35	97.88	91.68
33	Hawi	95.90	94.83	91.38
34	Olowalu	97.99	92.51	90.96
35	Union Mill	92.87	97.17	90.72
36	Niulii	91.37	98.45	90.57
37	Waimea	97.07	92.92	90.48

TABLE NO. 10
SUMMARY OF LOSSES

FACTORY	Pounds Polarization per Ton of Cane: Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Polarization per 100 Cane: Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Polarization per 100 Polarization of Cane: Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Syrup Purity	FACTORY
H. C. & S. Co.	9.0	0.8	18.4	...	—1.6	26.6	0.45	0.04	0.92	...	—0.08	1.33	3.08	0.30	6.34	...	—0.52	9.20	87.91	H. C. & S. Co.
Oahu	7.0	0.6	20.4	...	1.6	29.6†	0.35	0.03	1.02	...	0.08	1.48†	2.49	0.21	7.22	...	0.55	10.47†	86.92	Oahu
Ewa	5.8	1.2	18.2	...	3.0	28.2	0.29	0.06	0.91	...	0.15	1.41	2.27	0.47	7.09	...	1.19	11.02	85.10	Ewa
Waialua	8.6	1.4	20.0	...	2.4	32.6	0.44	0.07	1.00	...	0.12	1.63	3.29	0.55	7.43	...	0.85	12.12	85.1	Waialua
Pioneer	5.6	0.4	19.2	...	2.2	27.4	0.28	0.02	0.96	...	0.11	1.37	1.94	0.17	6.66	...	0.73	9.50	86.87	Pioneer
Olaa	8.0	1.2	17.2	...	1.0	27.4	0.40	0.06	0.86	...	0.05	1.37	3.11	0.47	6.70	...	0.38	10.66	86.8	Olaa
Haw. Sug.	6.4	2.6	17.4	...	—1.8	24.6	0.32	0.13	0.87	...	—0.09	1.23	2.19	0.91	5.86	...	—0.60	8.36	87.82	Haw. Sug.
Maui Agr.	8.0	...	....	...	23.2	31.2†	0.40	...	...	...	1.16	1.56†	2.67	...	....	...	7.75	10.42†	88.90	Maui Agr.
Onomea	2.8	0.2	17.2	...	2.6	22.8	0.14	0.01	0.86	...	0.13	1.14	1.11	0.09	6.82	...	1.01	9.03	87.72	Onomea
Lihue	6.0	0.6	18.0	...	0.6	25.2*	0.30	0.03	0.90	...	0.03	1.26*	2.38	0.28	7.18	...	0.25	10.09*	83.62	Lihue
Haw. Agr.	7.4	0.4	18.4	...	5.2	31.4	0.37	0.02	0.92	...	0.26	1.57	3.14	0.20	7.78	...	2.16	13.28	67.74	Haw. Agr.
Hakalau	2.8	0.2	16.8	...	0.6	20.4	0.14	0.01	0.84	...	0.03	1.02	1.10	0.11	6.52	...	0.23	7.96	85.9	Hakalau
Honolulu	7.2	0.4	27.0	1.2	...	....	0.36	0.02	1.35	0.06	...	...	2.55	0.13	9.51	0.40	....	....	80.62	Honolulu
Kekaha	4.2	1.6	22.6	...	1.4	29.8	0.21	0.08	1.13	...	0.07	1.49	1.52	0.61	8.18	...	0.49	10.80	86.2	Kekaha
Hilo	3.4	0.8	18.8	...	0.8	23.8	0.17	0.04	0.94	...	0.04	1.19	1.40	0.37	7.77	...	0.35	9.89	86.33	Hilo
Wailuku	5.2	1.2	18.6	...	1.0	26.0	0.26	0.06	0.93	...	0.05	1.30	1.93	0.43	6.89	...	0.40	9.65	87.2	Wailuku
McBryde	8.0	0.8	21.2	...	...	30.0	0.40	0.04	1.06	...	....	1.50	2.89	0.29	7.70	...	....	10.88	86.63	McBryde
Makee	7.0	0.8	21.2	...	3.0	32.0	0.35	0.04	1.06	...	0.15	1.60	2.84	0.35	8.62	...	1.23	13.04	84.27	Makee
Honokaa	8.0	0.8	19.0	...	1.2	29.0	0.40	0.04	0.95	...	0.06	1.45	3.51	0.35	8.25	...	0.54	12.65	84.39	Honokaa
Laupahoehoe	8.4	0.4	16.2	...	5.2	30.2	0.42	0.02	0.81	...	0.26	1.51	3.28	0.11	6.37	...	2.07	11.83	87.33	Laupahoehoe
Pepeekeo	4.6	0.4	14.6	...	4.2	23.8	0.23	0.02	0.73	...	0.21	1.19	1.79	0.14	5.79	...	1.65	9.37	86.2	Pepeekeo
Hamakua	6.6	...	24.4	...	2.2	33.2	0.33	...	1.22	...	0.11	1.66	2.64	...	9.82	...	0.86	13.32	86.02	Hamakua
Kahuku	8.4	1.2	19.2	...	0.2	29.0*	0.42	0.06	0.96	...	0.01	1.45*	3.37	0.53	7.71	...	0.10	11.71*	82.25	Kahuku
Paauhau	6.0	0.6	19.4	...	2.2	28.2	0.30	0.03	0.97	...	0.11	1.41	2.49	0.23	8.15	...	0.90	11.77	85.5	Paauhau
Honomu	4.4	0.8	17.8	...	0.8	23.8	0.22	0.04	0.89	...	0.04	1.19	1.73	0.32	6.97	...	0.32	9.34	86.3	Honomu
Koloa	8.0	2.0	23.2	...	7.2	40.4	0.40	0.10	1.16	...	0.36	2.02	3.17	0.80	9.06	...	2.83	15.86	83.2	Koloa
Waiakea	12.6	1.2	19.4	...	1.6	34.8	0.63	0.06	0.97	...	0.08	1.74	4.73	0.48	7.36	...	0.60	13.17	87.19	Waiakea
Hutchinson	7.2	1.0	20.6	...	1.8	30.6	0.36	0.05	1.03	...	0.09	1.53	3.12	0.43	8.91	...	0.75	13.21	85.79	Hutchinson
Hawi	11.2	1.0	28.0	...	...	40.2	0.56	0.05	1.40	...	....	2.01	4.10	0.34	10.33	...	0.02	14.79	87.8	Hawi
Waianae	8.4	1.8	...	...	35.2	45.4	0.42	0.09	...	...	1.76	2.27	3.12	0.68	....	...	12.99	16.79	83.43	Waianae
Kaiwiki	9.4	2.0	20.6	...	0.8	32.8	0.47	0.10	1.03	...	0.04	1.64	3.65	0.76	8.01	...	0.28	12.70	87.61	Kaiwiki
Kohala	9.2	2.4	18.6	...	3.4	33.6	0.46	0.12	0.93	...	0.17	1.68	3.61	0.97	7.24	...	1.34	13.16	86.03	Kohala
Kilauea	8.0	2.4	21.4	...	4.2	36.0	0.40	0.12	1.07	...	0.21	1.80	3.23	0.97	8.57	...	1.70	14.47	83.4	Kilauea
Kaeleku	11.8	1.4	18.4	...	3.4	35.0	0.59	0.07	0.92	...	0.17	1.75	4.96	0.57	7.76	...	1.46	14.75	84.04	Kaeleku
Waimanalo	3.0	2.2	22.8	...	3.0	31.0	0.15	0.11	1.14	...	0.15	1.55	1.13	0.80	8.59	...	1.09	11.61	84.93	Waimanalo
Halawa	16.0	2.8	...	...	20.4	39.2	0.80	0.14	...	...	1.02	1.96	6.65	1.21	....	...	8.46	16.32	85.18	Halawa
Union Mill	18.0	3.2	20.4	...	0.6	42.2	0.90	0.16	1.02	...	0.03	2.11	7.13	1.29	8.13	...	0.23	16.78	86.3	Union Mill
Waimea	7.8	1.0	...	...	38.4	47.2	0.39	0.05	...	...	1.92	2.36	2.92	0.41	....	...	14.42	17.75	85.44	Waimea
Olowalu	5.2	1.2	27.2	...	14.8	48.4	0.26	0.06	1.36	...	0.74	2.42	2.01	0.43	10.31	...	5.64	18.39	83.2	Olowalu
Niulii	20.6	1.0	...	...	20.0	41.6	1.03	0.05	...	...	1.00	2.08	8.63	0.46	....	...	8.32	17.41	85.41	Niulii

* A comparison of the available sucrose in the juice with the amount recovered in the boiling-house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

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Early Fertilization

The importance of early fertilization is being realized more and more throughout the world. The Louisiana sugar planters, with their heavy rainfall, are now turning to early fertilization with nitrate of soda in addition to acid phosphate. This is a change from cottonseed meal and tankage. Dr. Schurig-Markee, a leading German agriculturist, recommends the application of nitrogenous fertilizers "as early as possible, and in one application instead of several." Of course this is for shorter crops than ours in Hawaii.

A Discussion of the Root Rot Problem*

By W. T. McGeorge

Certain phases of the investigations being conducted on the root rot problem, which appear to be pertinent to our own local problems and a short discussion of the results which we have obtained in the researches being conducted at the Sugar Planters' Experiment Station, are herewith presented. To begin with, there is more or less confusion in the use of the term root rot. In sugar cane it is an outgrowth of the older term Lahaina disease. We would anticipate the association of the retarded root development in most cases of plant failure from a number of influences, and such occur in practice. It has been generally assumed that it is safe to attribute the retarded development of the plant as a whole as secondary to root failure. This assumption has been the incentive for many years of search of the bacterial and fungi flora of our soils for causal organisms. As you may know, failure in this line of investigation is widely admitted, although there are not lacking a number who still cling to the strictly pathological phase of root rot. What I mean to infer by the above is that the too general application of the term root rot is unfair.

* Presented at meeting of Hawaiian Section of American Chemical Society, Honolulu, November 1, 1924.

Rapid strides in the progress of methods of soil research during the last ten years have provided or armed us with better methods or weapons of attack for such problems. As related to investigations in plant failure the progress of soil and physiological chemists in the study of soil toxins and plant nutrition should be mentioned. The more accurate methods of measuring soil reaction and a method for removing the soil solution for study are of interest.

Before proceeding further it may be best to briefly review our local problem. A casual survey of the Island districts in which Lahaina cane failed and where conditions diagnosed as root rot prevail shows a startling variety of soil types of equally varying properties, mostly abnormal. To mention a few of these, the acid soils of the Hilo-Olaa and Hamakua districts deficient in potash and high in ferrous iron and organic matter; some alkaline soils on Maui; on Oahu the Kaneohe soils of high acidity, high in soluble iron aluminum and manganese salts and deficient in both potash and phosphate; the lower fields of Ewa-Puuloa district, which are alkaline or nearly neutral; the mauka fields on Kauai and other upland areas which are similar in many ways to those at Kaneohe.

The description of the condition of plants as observed by various members of the station staff also shows some variation.

While fungi or other organisms have always been found, by the pathologists, present in the rotted roots, the discovery of a primary causal fungus has not been effected in spite of many intensive investigations. Dr. Lyon, as early as 1915, stated that we may eliminate senility and parasitic organisms as a plausible explanation for Lahaina disease. In view of this I will therefore omit a review of the pathological phase of root rot studies made in the Islands.

It is obvious from past observations that we are led to assume the association of the ever present fungi as a secondary factor only, and that some other agent resident in the soil is the primary cause. I think that I may safely say that the principal mistakes and failures of the past have been due to the apparent assumptions that root rot is the result of a single causal agent in all cases rather than a general problem involving a number of phases of soil infertility. At least it is true that the most promising results in Europe and on the mainland have been obtained and the greatest progress made by the investigators who have treated the problem as a complex.

In our own soils several possible primary chemical, physical and bacteriological factors suggest themselves and all have been found to be definitely associated with soil infertility.

1. Climatic conditions, such as rainfall and temperature, not within the range of adaptation of the plant or variety. For example, H 109 is totally unsuited to many Island localities, yet we hear no mention of H 109 disease.

2. Poor physical condition of the soil which inhibits proper aeration for root respiration.

3. The presence of soluble substances in the soil solution which are toxic toward plant growth. These include many organic and inorganic compounds of known toxicity.

4. Conditions productive of abnormal or subnormal activity of soil microorganisms.

5. Plant food deficiencies or excess, more especially the former at certain critical periods in the development of the plant. This would include nutritional disturbances or abnormally balanced nutrients.

The Chemical department of the Experiment Station has, during the last several years, reopened the root rot problem and treated it along the lines suggested by a knowledge of our soil types and on the basis of several lines of investigation being intensively pursued in Europe and on the mainland. The results thus far have yielded some extremely illuminating data. Our studies to date have been confined almost entirely to acid soils so that this discussion will be limited to them.

During the last summer I had the opportunity of visiting a number of agricultural institutions on the mainland and comparing the progress of our work with theirs. The similarity of our observations was amazing and I will discuss some of these in detail.

At the Indiana Experiment Station, Dr. G. N. Hoffer, specialist in plant physiology and pathology, is studying the problem. He is probably the leading investigator on the problem of aluminum toxicity, a factor which has been shown to be definitely associated with corn root rot in the Middle West as the primary causal agent. It is significant in his work that he avoids being led into single channels of investigation through the discovery of dominant factors. That is, he continually keeps in mind all possible associated factors which are present and which may contribute to plant failure. It is also significant that in spite of the fact that he is a pathologist and has given careful attention to the fungi flora of the decayed roots he has found chemical factors playing the primary role. In other words, he has not succeeded in producing root rot in a properly nourished plant by inoculation with any of the contributing organisms. A few words regarding his theories and methods of study are of interest.

He divides plant growth into three zones: health, susceptibility and toxicity. The zone of health is defined as the environment conducive of optimum plant growth; that of toxicity as having sufficient concentration of toxin or other inhibiting factor to seriously or completely inhibit plant growth of itself. Within the zone of susceptibility we have an environment productive of sufficient loss of plant vitality to predispose the plant to the invasion of organisms. Within this zone we have only subtoxic concentrations of toxins and plant food deficiencies as factors which lower plant resistance, and within this zone most problems in soil fertility arise.

Root rot in the toxic zone makes its appearance in the young plants, the concentration of toxic agent being sufficient to entirely retard even subnormal development.

In this connection, while Whitney and Cameron's original suggestion that plant roots secrete toxins is not considered entirely correct, on the other hand it has been shown that while healthy roots secrete CO_2 only, if the oxygen supply is limited by poor aeration the roots will secrete organic acids. These acids could act as solvents for aluminum producing aluminum toxicity in immediate contact with the roots even in an alkaline soil.

Within the zone of susceptibility his theory as to plant failure in corn attributes root rot to be secondary to notable disturbances which he has discovered in the stalk. He finds that growth retarding factors induce accumulations of iron

and aluminum at the nodal joints. There results a discoloration of the vascular plate tissues and a certain degree of disintegration. Dr. Hoffer believes that this nodal accumulation precedes the rotting of the roots, the channels of food transmission within the plant being disrupted. There results also increased enzymatic activities in the plant juice, a setting of the protoplasm and other abnormal conditions. Thus aluminum and iron become inhibiting growth factors even in the absence of appreciable solubility in the soil solution. To further explain Hoffer's theory, he has shown by experiment that where retarded growth is induced by a deficiency of potash or phosphate the vitality is lowered sufficiently to permit the fungi invasion.

In sugar cane we find these same nodal accumulations of iron and aluminum regardless of their solubility in the soil. Wherever the stalk is stunted, whether on acid soils, soils of high saline concentration, or even on the short winter growth of the stalks these elements accumulate.

Independent of Hoffer, Bodnar at the Royal Hungarian Institute of Plant Physiology also found a predisposition of the plant tissues to fungus invasion in the presence of high aluminum absorption. His problem was the root rot of sugar beet. As one phase of his investigation he analyzed normal beets, badly rotted beets and partially rotted beets. In the latter he analyzed the healthy and affected parts separately. The principal difference in the composition of the ash was the greater aluminum content of the rotted bulbs. (Diseased beets 6.8-10.2 per cent and healthy beets 1.28-2.57 per cent.) Also, he found the aluminum content of the diseased portion of a single beet to be higher in aluminum than the healthy portion. One of the conclusions reached in his work was that the increase in aluminum content of the beet precedes the invasion of the organism and predisposes the tissues.

Having shown the presence of soluble iron, aluminum and manganese in the Island soils, our initial studies involved the identification of the types in which the salts of these elements are actually present in the soil solution. A method for determining the so-called active aluminum has been published by the Rhode Island Experiment Station. We have, however, adopted a different and, I think, a better procedure and have determined the range of H ion concentration at which it is possible to have these salts present in the soil solution. This investigation showed that all soils of H ion concentration greater than that represented by pH 5.8 fall in this class. Above this pH we must search for other factors where root rot is present. Many of our soils have pH below 5.8 and root rot is prevalent in many such fields. This higher acidity is typical of upland soils and includes a large percentage of the pineapple as well as many of the sugar lands.

Now as for the toxicity of the salts of the elements iron, aluminum and manganese toward sugar cane we have carried out several hundred cultural experiments which have included several of the salts of these elements and of the representative varieties of sugar cane. It will be impossible to more than touch upon these experiments. Suffice it to say that aluminum salts showed a marked toxicity toward sugar cane, with less resistance in the Lahaina variety.

As for methods of correcting aluminum toxicity in soils there are several possible. These include the precipitation of aluminum in an insoluble form; for example, the phosphate by additions of superphosphate, or by changing the soil

reaction by such neutralizing agents as lime or molasses ash. Our field experiments have not progressed sufficiently to warrant comment. On the other hand, in pot experiments using acid Island soils notable response and remarkable root stimulation has been obtained. These experiments showed that phosphate applications give only temporary response due to the high potential aluminum content of our soils and the fact that the reaction of the soil is not changed by the phosphate application. In our experiments an application of 20 tons superphosphate per acre was completely inactivated in four months time and the original toxicity of the soil had returned. The practical reclamation of such soil types must therefore necessarily involve the use of some neutralizer as a corrective agent; the use of lime has, however, not given immediate response, but this is more or less to be expected. Acid soils of the reaction, at which we find aluminum showing toxicity, are notable for the presence of numerous growth retarding agents. Subnormal bacterial activity, which is characteristic of unfavorable growth media may be mentioned. Also, the poor physical condition and notable plant food deficiencies which are characteristic of these acid types. Organic decomposition in acid soils is notably productive of organic and inorganic compounds unfavorable to plant growth. It is evident therefore that the correction of aluminum toxicity may be only one factor. In Indiana, it is the practice to add 3-4 tons lime per acre plus 500-1000 lbs. superphosphate and then plant to a resistant crop before going to corn. Dr. Conner of the Indiana station, who has had practically twenty years experience with such soil types, in a discussion of the action of lime has the following to say: "We have never been able to grow a normal corn crop on this soil, even with limestone applications up to 14 tons per acre until after a lapse of three years. It is quite possible that aluminum hydrate remains toxic until it is gradually fixed as a single or double silicate or phosphate or as a more insoluble hydroxide. At any rate plenty of available phosphate or silicate hastens the improvement in fertility and crop producing power."

I was much interested at the last pineapple short course at the University of Hawaii to hear statements by two men of wide experience in pineapple culture that liming in the long run had shown some improvement in fertility. A significant case which came to our own attention recently also is of interest. Two samples of soil submitted to our laboratory for examination from Koloa Plantation represented a field which was of poor fertility and a section of this same field which had formerly been a road and on which the cane was making very good growth. The soil was a typical upland soil of high acidity and low in available potash and phosphate. The reaction of the field in general was pH 4.6 and of the former road pH 6.0. Dr. Hoffer has noted a similar situation in an Indiana corn field. The reaction of a field showing root rot had a pH 5.6. In another part of this same field where the corn showed no root rot the reaction was pH 6.2. There is a warning in the above instances against too hasty conclusions from liming experiments. There are too many possible inhibiting factors present in acid soils which may only be corrected in full over extended periods.

During the past summer I saw on the mainland experimental plots which had been receiving ammonium sulphate (without lime) for a period of fifteen years and had reached a condition in which few crops would grow. The only difference between these plots and the check plots was the higher acidity of the

ammonium sulphate plots and the presence of soluble aluminum. When we start liming acid soils, that is, the naturally acid types, let us not forget that those soils have been acid probably for thousands of years and their reclamation may involve unforeseen complexities requiring patience and careful study.

Returning to Dr. Hoffer's zoning of plant growth, let us apply his line of reasoning to some past experiments on the root rot of Lahaina cane. In 1915, Dr. Lyon transferred a sick stool of Lahaina to our Experiment Station soil (which has never shown root rot) and obtained a complete recovery of the stool. In making this transfer he carried the secondary factor (the fungus) into the good soil in which the primary factor was lacking. In the absence of the primary factor the plant recovered on failure of the fungus or secondary factor to play its role effectively in the absence of the primary predisposing agent. This experiment has been repeated recently by Mr. Lee, who transferred "sick" Lahaina stools from Puunene to the Station soil with the same results. This same line of reasoning clarifies some of Carpenter's observations. On sterilizing sick soils he obtained some improvement in plant growth, having removed the secondary factor, the primary factor being present only in subtoxic concentrations. On reinoculating the sterilized soil with pythium type fungus, thereby again reproducing the association of primary and secondary factors, he again produced the root rot.

The outstanding feature of these root rot problems is the comparative resistance of varieties and individual plants. For example, going into a pineapple field one is immediately struck by the apparently normal growth being made by some plants, yet entirely surrounded by wilted plants. The same is true, only less strikingly so, of sugar cane. We see a heavy stand of H 109 where Lahaina scarcely goes beyond the germination stage. The question arises what is the inherent characteristic of these resistant varieties or plants which imparts this power of resistance and can it be determined? We are analyzing many plants grown in our pot cultures which we hope may throw some light on the chemical phase of this question.

Dr. Hoffer has found that there is a definite relation between the phosphate requirement and degree of resistance to aluminum toxicity. That is to say, a plant or variety having a high phosphate requirement will develop root rot more rapidly in the presence of a deficiency, and a phosphate deficiency has been shown to be related to aluminum toxicity and is usually a characteristic of acid soils. Therefore the variety with lowest phosphate requirements shows the greatest degree of resistance. He has even developed this phase of his investigations to such a degree that he can determine the resistance of a seedling by chemical analysis and is using this extensively in breeding corn varieties for resistant strains. He is also studying the selective absorption of iron and aluminum as a heritable character in corn.

Another interesting angle on root rot resistant characters has been uncovered at the Rhode Island station. They find that crops to which aluminum is toxic show a wide variation in mineral composition when grown under different conditions. For example, the carrot shows little variation in mineral composition regardless of environment under which it is grown and is highly resistant. In other words, the ability of the plant to obtain its needs under adverse conditions;

that is, to select its likes and reject its dislikes is a notable resistant character. It is not unfair to assume just some such relation as this in comparing H 109 and Lahaina on high saline concentrations, the H 109 having the greater power of selection.

Again, potash has been found to be an important factor and possesses an essential function in relative resistance. Sherwin, in North Carolina, working on a non-productive soil of pH 3.5 to 5.0, found heavy nodal accumulations in corn, which was suffering from root rot on this soil. Unlike previous experiments on such acid soils this soil did not respond to phosphate applications, but did respond notably to potash and lime. Hoffer, cooperating in these experiments, discovered the function of the potash. He found that potash possesses the property of greatly decreasing or entirely eliminating the nodal accumulations of iron and aluminum. Its action is within the plant. I might add at this point that in our pot experiments we obtained similar results, namely, that by increasing the potash reserve in the plant there was a marked stimulation in plant growth in spite of the fact that the aluminum content and solubility in the soil had not been altered. If a toxin can be cared for within the plant as rapidly as it enters, then the plant is not injured. Dr. Hoffer has further noted a remarkable difference in the appearance of plants in which phosphate and potash separately are limiting factors. In other words we might say that two distinct types of root rot have been described by Hoffer, depending on the nature of the deficiency which is associated with the aluminum. How many more distinct types there are can only be conjectured.

In closing, the point which I wish to emphasize is that we are dealing with a very complex problem. Investigations throughout the world as well as our own have proven this beyond question. The conditions of optimum environment for plant growth include plant food, moisture, air, sunlight and temperature. Everyone must realize the difficulties attached to the maintenance of all these conditions at optimum. It is widely recognized that with any departure of any one of these conditions from the optimum or the entrance of an inhibiting toxic factor the plant may be affected in its growth and is often rendered more susceptible to diseases which would scarcely invade the tissues when in normal vigor.

The root rot problem is therefore more than a "one man job," and as long as we continue to treat it as a single line of research our progress is bound to be slow. That is to say, it is not a problem in chemical research, or pathological research alone. In the past it has been treated more or less like a game of volley-ball. First it was taken up by the pathologists, then thrown at the chemists, back again at the pathologists and, finally, once more at the chemists. It is a research problem involving the imperative close cooperation in lines of chemical or soil research, the morphological study of the plant tissues and plant processes as well as the pathological investigation of the parasitic and saprophytic characteristics of the associated fungi and possibly other yet unforeseen factors.

Our investigations to date are extremely encouraging, to say the least, and I feel that its solution is highly probable if the proper cooperation can be obtained.

A Study of the Cane Borer, *R. Obscura*, and Its Parasite, *C. Sphenophori*, at Paauhau Sugar Plantation Company

By C. E. Pemberton

Introduction

With the gradual reduction in acreage of Yellow Caledonia cane, since 1918, in the Hamakua district of the island of Hawaii, and its replacement with the varieties D 1135 and H 109, there has been a noticeable increase in damage by the beetle borer, *Rhabdocnemis obscura,* if we are to judge from the frequently expressed complaints since 1920. This increase is readily explainable from the cane variety point of view, for D 1135 and H 109 are more favorable for borer development than Yellow Caledonia. They are primarily more susceptible because softer. However, were we to attribute the increased borer damage solely to a change of varieties, we would expect similar damage elsewhere where D 1135 or H 109 have extensively replaced Yellow Caledonia. This is not so. The explanation is complex, involving a consideration of both the climatic conditions of Hamakua and the change of cane varieties in their combined influence upon the activities of the borer, as well as the meteorologic effects upon the cane, which result disadvantageously to the parasite.

At the urgent request in 1923 of Mr. F. M. Anderson, Manager of Paauhau Sugar Plantation Company, and through the suggestion of C. Brewer & Company, Ltd., a study of the situation at Paauhau was begun in February, 1924, and continued through the harvest season until October.

As the borer parasite (*Ceromasia sphenophori*) now effectively controls the pest over most of the other plantations in Hawaii, this investigation dealt almost exclusively with a study of the parasite, as it operates in Hamakua. Some fear had been expressed that its activities might be hampered by factors peculiar to the district. It was felt that perhaps an understanding of these factors, if present, might lead to their control, with a consequent alleviation of the losses. This work, therefore, has been largely a study of the parasite, in every phase of its complete cycle, and, as the data which follow show, establishes what we feel to be ample proof, that the difficulty in Hamakua is climatic and one of varietal change, rather than one of loss of vigor in the parasite or of the presence of enemies inimical to it.

As just indicated, we feel that Yellow Caledonia is less susceptible to borer injury than the varieties D 1135 or H 109, because harder. The data covering extent of borer damage among the three varieties have not been extensive enough clearly to demonstrate this, however. In fact, in some scattered counts the reverse conclusion might be drawn.

Extent of Borer Damage

The data at hand respecting the percentage of sticks damaged by borer at Paauhau and Honokaa are convincing of the importance of the losses, but not extensive. This side of the study was necessarily sacrificed in order that a thorough investigation could be made of the parasite. Estimates by Mr. Raymond Elliott, Chemist of Paauhau Sugar Plantation Company, of the extent of borer damage in several fields at Paauhau in 1923, gave an average of 26.48 per cent of the stalks damaged and in 1924 an average of 27.17 per cent. In a comprehensive series of analyses, made by him in 1924, on sound and borer-injured cane from five separate fields, his conclusions show a surprising sugar loss occurring in these fields. These data, presented at the Third Annual Meeting of the Association of Hawaiian Sugar Technologists in October, 1924, indicated an average monetary loss for the five fields of $42.30 per acre, with sugar at 7 cents. In this computation, 27.17 per cent of the sticks analyzed were borer injured. If we apply these figures to the data shown in Table 1, covering counts made by the writer at Honokaa, Paauhau and Hakalau during 1923, we may logically assume that the cane borer actually levies a heavy tax on large areas of cane in Hamakua and to some extent, occasionally, in certain low fields as far along the coast as Hakalau. When we see, however, the extent of control that is being constantly exerted over the borer by the introduced parasite, as shown in Table 2, no stretch of the imagination is needed to comprehend what a really large loss would inevitably occur, were it not for this continual parasitic check. With losses in Hamakua as they now are, in spite of a 44 per cent destruction of the borers by the parasite, what would they be without this check?

Table 1 should give a fair estimate of the extent of borer damage as it occurred in 21 fields of Honokaa Sugar Company in 1923. A total of 15,900 sticks were examined. This examination showed an average of 22.7 per cent of the sticks injured to some extent by the borer. These counts were made at random over the fields, and though not large, indicate distinctly that the borer problem is one of importance on the plantation. The fields show damage ranging from nothing to 48 per cent, the cane being mostly D 1135. Of interest is a count of 1,000 sticks of Uba cane, under harvest in Field 24, Honokaa Sugar Company, where no borered sticks were found whatever. This is not always the case, as later observation showed, but Uba is clearly less susceptible to borer injury than D 1135 or H 109.

In general, the cane at Honokaa cut in 1924 appeared to have somewhat less damage than in 1923, owing to the greater amount of short ratoons cut and in part to rat control. A brief discussion of the relation of short ratooning to borer development occurs elsewhere in this paper.

Borer damage in Hamakua is usually much more severe in fields below the 1000 ft. level than above. The lower the fields, generally the more acute the damage. The only high fields in Table 1 are the first five. The average damage for these is well below that of the remaining sixteen fields, taken collectively.

Apart from the percentage counts of borer damage, made by Mr. Elliott, referred to above, three counts were made at Paauhau in April, 1923, as shown in Table 1. These covered a total of 4,500 canes in three fields. An effort was

made to secure counts giving average conditions. They show an average of 12.5 per cent of the sticks damaged, with a maximum of 18.6 per cent in a field of H 109 and a minimum of 4.8 per cent in a field of D 1135, the Yellow Caledonia field falling between with a damage of 14.3 per cent. These figures can only be indicative of the occurrence of considerable loss, as they are not extensive enough to accurately measure the field loss or varietal susceptibility.

As further shown in Table 1, losses from cane borer may be considerable even at Hakalau. At the request of Mr. Ross in August, 1923, a count was made in Field 2, Hakalau Plantation Company, in 15 months old, short ratoon, Yellow Caledonia cane. This field, at a low elevation, showed a good deal of damage, though, as is frequent in this variety, many of the canes damaged would bear the injury only in a single joint. The count, covering 6,000 sticks, gave a borer damage of 16.8 per cent. This should be close to the actual percentage of canes borer injured in this field. It is believed that this degree of injury is exceptional for Hakalau, however.

Borer Parasitism at Paauhau

The complete results embodying the study of parasitism of the cane borer at Paauhau Sugar Plantation Company are summarized in Table 2. A brief discussion with conclusions drawn is necessary in explanation of the facts indicated therein and in Tables 3 and 5 elaborated from it.

A fairly exact understanding of the operations and benefits derived from this parasite, can be obtained through careful dissection of the borer channels in the canes, providing these dissections are made on a large scale, covering representative areas over the fields under investigation. These channels, old and new, contain the entire history of what has already occurred or may be occurring in the unceasing struggle between the borer and its enemy, the fly. Old channels, often formed 15 to 20 months previous to the examination, unless completely destroyed or cleaned out by ants, contain the record of parasitism or non-parasitism. If a borer-grub has succeeded in developing to maturity without being found and destroyed by the parasite, the original borer cocoon, from which the beetle has hatched out, still lies in the channel, empty. Being empty is indicative that the beetle matured and escaped unharmed. If the record is more recent and a grub has matured, escaped attack by the parasite and changed to the pupal stage, which is then uninteresting to the fly maggot, this borer pupa lies exposed for our record also, as an unparasitized individual. However, if a grub, many months, or even a year or more previous to our examination, has been reached by the wriggling maggots of the fly, and thus destroyed by them, the cocoon which the grub weaves, even though parasitized, will contain the empty shells of the fly pupae which have developed from these maggots. These empty shells (puparia) are absolute evidence of parasitism, even though the borer-grub had been destroyed and the flies developed and escaped long since. Again, these borer-cocoons may contain the fly pupae or developing flies themselves, which indicates recent parasitism. Still further, the borer channel may contain a living borer grub. The dissection of this shows readily the presence or absence of parasites, in the form of pale, white maggots of varying size, dependent upon their period

of residence within the body of the grub. The dissection then of each borer channel reveals the history, past and present, of the work of the parasite, indicating wherein it has succeeded in reaching grubs and just how often it has failed.

During the 8 months time devoted somewhat intermittently to these dissections, a total of 11,704 borer channels, in 5,819 grub-injured canes, were dissected out in their varied ramifications, covering four fields carefully and two in part.

The data for each variety of cane, in each field, were segregated. As no clearly marked difference could be discerned in degree of parasitism in one variety of cane over another, this differentiation in variety is not shown in Table 2.

The actual percentage of borer grubs destroyed by the parasite during the entire period of growth of the cane in the 6 fields examined, ranged from 36.5 per cent to 56 per cent, with an average for the 6 fields of 44.6 per cent. This is a much more satisfactory degree of parasitism than we had anticipated. During the examinations, parts of fields at times showed very low control. Often for a week or more, the canes consistently showed parasitism ranging below 10 per cent. However, there was considerable fluctuation in each field. This demonstrated the need for a wide series of records, and the average for each field, as a whole, as finally summarized, was much higher. These localized spots, both at Honokaa and Paauhau, where the parasitism is often very low, are generally areas of dense growth in the bottom of hollows, large and small, or in low fields where the cane has been long-ratooned, has been much bent over and often broken by wind and where trash and sometimes weed and grass growth has become thick, matted and protective of the hidden canes near the ground, thus almost completely excluding the fly in its efforts to reach the grub infested parts of the canes.

A total of 2,910 borer grubs were cut open and evidence of parasitism therein determined. Of these, 12.3 per cent contained larvae of the Tachinid fly, totaling 1,107 maggots, or an average of 3.0 per parasitized grub. The greatest number of maggots found in one grub was 12. Many grubs were opened that contained but 1 maggot, some with 9 or 10 and three with 11 maggots. As many of the grubs examined might have become parasitized in the field, before maturing, if left undisturbed, we cannot use this data as the absolute test of the degree of parasitism occurring in the fields examined. It only gives data on the seasonal activity of the parasite. The actual extent of parasitism is determined from a borer cocoon examination. As described above, the past as well as the present history of cane borer parasitism in each stick, is bound up in the cocoons in the stalk.

From a total of 6,171 cocoons opened and examined, 2,638 contained fly pupae or empty fly pupal shells (puparia). This gives an actual parasitism, based on the whole series of cocoon examinations combined, of 42.7 per cent, and as given above, if based on the separate totals of the 6 fields, a parasitism of 44.6 per cent. These figures should fall close to the actual degree of control exerted by the parasite over the borer in the Paauhau fields studied.

A total of 7,331 fly pupae or puparia were removed from these 2,638 cocoons, which gives an average of 2.8 per cocoon. This is close to the figure recorded

above (3.0) for the average number of fly maggots occurring in living borer grubs. The greatest number of fly pupae or puparia per cocoon was 11. Many contained only one and several had 8, 9 and 10 per cocoon.

These are interesting data, bearing on the life habits of the parasite, for they check well with similar data computed by Mr. Muir in his original observations on this parasite at the time of his discovery and introduction of it to Hawaii.

As already stated, many old borer channels in the cane become entirely cleaned and occupied by ants, particularly the big headed brown ant *Pheidole megacephala.* As nothing of the parasitism record remains in these channels, they must necessarily be left out in the computations. There are many of them. During the period of borer study at Paauhau, a total of 2,069 such channels were cut out, from which no evidence remained with which to record parasitism data.

The information in Table 3 is illuminating in explanation of the seasonal activity of the parasite. It shows distinctly that the parasite is much more active and effective during the summer months in Hamakua than in the winter. In February, March and April, the percentage of developing parasitic larvae or pupae present, as compared with the percentage of old, empty, fly pupal shells (puparia), was less than half that of May, June, July or August. In other words, in the summer months, fly larvae, pupae and hence adult flies, were easily twice as numerous, by percentage counts, as in the spring, fall or winter months.

In the entire series of examinations the records of parasitism and borer attack, as they occurred separately in the top, middle, lower part and bottom of each stalk, were segregated for each section of the stick. A comparison of these data gives us useful information. This tabulation is shown in Tables 4 and 5. Of 11,704 borer channels examined, 16.6 per cent occurred in the top portion of the stick, 22.4 per cent in the middle section, 31.5 per cent in the lower 3 feet and 29.5 per cent in the bottom one foot of the stick. Thus the first four feet of cane above ground contained 60.9 per cent of the borer channels and the bottom one foot of cane almost one-third of the total number in the entire stick.

As shown in Table 4, the parasitic control of the grubs is poorest in the bottom of the stick and best in the second, third and fourth feet of cane. It is also fair in the middle and top. These are not necessarily iron bound conclusions. They are based only on the facts as they appeared in this particular investigation. It is safe to conclude, however, that in general, under the present methods of agriculture in Hamakua, the bottom portion of the canes will have the most borers and show a lower degree of parasitism than in any other part of the stick.

A careful watch was kept for predatory or parasitic enemies of the fly, in all stages, during the entire period of study. None were found. No indications of parasites on the fly larvae were detected and nothing but flies emerged from a large number of fly pupae saved.

The fields selected for study represented long and short ratoons. No decided difference could be seen in the degree of borer-parasitism between the two, though field examinations both at Honokaa and Paauhau in young cane up to 1 year of age, in general show a higher degree of parasitism than in older cane. The amount of borer damage in any field must necessarily be increasingly greater the older the cane becomes. The accumulated damage per stick is naturally greater in cane exposed to borer for 2 years than 1½ years or any shorter period. This

is self evident and in spite of occasional casual comparative counts in long and short ra'oons, which may show more damage in the latter; any one field will, of course, have more damage the longer it remains in the field. It is simply accumulative.

The great improvement in juice purity and sugar yield in Hamakua, in recent short-ratooning tests, particularly at Honokaa, clearly demonstrates that the same operation, if adopted as a means of borer control, in no way endangers the sugar output of a field.

Table 6 gives data secured by Mr. Swezey at various plantations on Maui, Oahu and Kauai during 1924-25. These figures show in general a fair degree of parasitism at each place. They were obtained incident to other work and hence do not cover large counts, excepting at the H. S. P. A. Experiment Station in Honolulu. This count shows a fairly satisfactory degree of control. They all tend to show that the Tachinid fly is no different in its operations at these places than in Hamakua, and further bears out our contention that the difficulty in Hamakua is climatic and one following cane varietal change, as explained elsewhere herein.

Factors Favoring the Borer in Hamakua

The following tables and conclusions drawn from them would indicate that the Tachinid fly in Hamakua possesses, in no lessened degree, the same vigorous potentialities for control of its host, the borer, that it has elsewhere in Hawaii where little borer damage occurs. In view of this we must look for other explanations of its inability to control this pest as thoroughly in Hamakua as in most other cane regions in Hawaii.

The frequent heavy winds of Hamakua, in their effect upon the cane, in combination with the change of variety from Yellow Caledonia to softer canes, would seem to explain the difficulty, but not remedy it. Very early in the growth of the cane, particularly in ratoons, borer infestation can be found. Fairly heavy infestation is often seen in cane only 4 or 5 feet high, if careful examination is made in the lowest joints. This results from the accumulation of adult beetles in the vicinity, in mature cane, the left overs from the crop that has just been removed and especially the heavy grub infestation in the stools themselves, left underground or near the surface in the stubble after harvesting. Much of this has been observed in borer-infested fields just harvested. As the cane continues growing, the borer grubs developing lie well exposed to parasitic attack usually until the cane is at least a year old. By then, in the low irrigated fields and hollows, it begins to bend over, frequently blows down in spots, and has commenced accumulating fair amounts of trash about the ground. Up to this point, as stated, conditions are satisfactory for parasitic attack on the grub, which permits a gradual multiplication and accumulation of the adult flies. From here on, however, this fly-increase, this perceptible gaining of the parasite over the borer, falls off. The balance then somewhat favors the borer. Were it not for the wind, in its periodic cracking and splitting effect upon these trash concealed parts of the stalks, the beetles would necessarily be obliged to place their eggs well above the trash, for they normally oviposit beneath live leaf sheaths where the newly found rind of the stick is not so hard as on the old joints.

The cane beetle has a very strong affinity for souring cane, for splits in the stalk, for spots opened by rat attack. This instinct is strong and has been repeatedly observed, for many years, by all who have studied the insect. Hence these cracks and breaks near the bottom of the canes, in and under the trash, which becomes heavier and more compacted as the cane grows older, furnish ideal spots for the beetle to place its eggs. It readily penetrates any trash, while the fly cannot. Were it not for such wounds in the lower part of the canes, no suitable tissue would exist there for beetle oviposition. In such cracks, breaks and splits, the eggs hatch and the grubs feed and develop to maturity in great part safely excluded from parasitic attack, because immersed in much compacted trash. We have good evidence of this in Tables 5 and 2, which distinctly show that the greatest number of borer channels at Paauhau, occur in the lower part of the stick and that the lowest degree of parsitism occurs there also.

On other plantations in Hawaii where there is no perceptible wind damage, the borer is well controlled by the parasite. Trash accumulates at many of these places, such as at Ewa, in even greater quantities than in Hamakua, because the yields are much heavier, yet there is no accumulation of suitable egg-laying spots in the trash-covered bases of the canes and the beetle must necessarily lay under the leaf sheaths well up on the cane. Most grubs then develop in places exposed and readily reached by the parasite. Suckers appearing in such trash can be suitable for borer development, but the period of their growth through this cover is short, and hence exposed to beetle attack while under the trash for a much smaller period than in broken or split cane-bases lying immovable within the trash.

In connection with this whole subject, we would venture the opinion that Yellow Caledonia is more wind-resistant than D 1135.

The relation of wind to borer damage was investigated briefly in Kohala. One field of D 1135, then under harvest, was examined. Borer damage in the small area examined was heavy. In tip canes at the same elevation damage was slight. There is no disputing the contention that this cane is more wind resistant than D 1135.

Occasionally the beetle borer accumulates to a noticeable degree in spots even on Oahu. This is in old cane usually. The older it becomes the more dead and fermenting canes naturally can be found in the trash. This softened material beneath and in the trash, furnishes suitable environment for beetle oviposition and grub development in tissue safely fortified against entrance of the fly.

General Conclusions

From the above, our only conclusion can be that plantations exposed to frequent and heavy winds in Hawaii, must inevitably suffer more or less from cane borer, when it becomes necessary to plant canes non-wind-resistant or comparatively soft. Some of the seedlings propagated at the Experiment Station, which were exceptionally soft, have proven highly susceptible to borers wherever planted.

We see no artificial method of cane husbandry which could be practically applied to completely remedy the trouble. We cannot recommend a change of varieties in Hamakua, for D 1135 is proving its high worth as a splendidly adapted cane for that district.

The future development of new varieties and tests of imported canes, such as the newly introduced Java seedlings, may in time offer a solution. The study and use of wind-resistant canes in Formosa is interesting, and may ultimately show us the value of such procedures in application to our wind-swept localities.

Several careful strippings and the clearing away of trash about the base of the stool should result in satisfactory parasitic control of the borer in Hamakua, but this expensive operation is probably impractical for more than one reason. Such clearing of the stool, for instance, would involve the piling of trash in the space between the rows and interfere with proper irrigation. Also, vigorous cane much over a year old is almost impossible to clean properly, at the base, because of the intricate bending and interlacing of adjacent stools in adjoining rows. Wider planting of the rows would serve to assist the parasite in its entrance of the stool and serve to spread out the trash and lessen the thickness of the blanket. It is doubtful, however, if a 6- or 7-foot spacing would prove profitable from an agricultural point of view. Were it not for this objection it should prove a useful adjunct in borer control.

The practice of short ratooning will improve the situation. Parasitism is best in young cane, for the reasons given elsewhere in this paper. Borer damage and beetle accumulation increase as the cane grows older. These two facts are indisputable. We feel that the wider the practice of short ratooning becomes, in the low fields of Hamakua, the better will be the borer control. Heavy damage as now sometimes occurs in short ratoons should not discourage one in the final acceptance of this view. The wider the policy of short ratooning, the more accumulative becomes the parasite in its operation over the entire district and the less accumulative the beetle. This is inevitable, as just inferred. It is a matter of simple reasoning, based on our knowledge of the development and interrelated habits of beetle and parasite.

We await with interest and much hope the outcome of efforts to be made during 1925 to locate further natural enemies of this pest in its native haunts in parts of the Malay Archipelago.

TABLE 1

EXTENT OF CANE BORER DAMAGE IN 1923

Honokaa Sugar Company

Field	Variety	Dates of Examination	Total No. Canes Examined	Average per Cent of Canes Borer Injured
1	D 1135	March 12	200	9.5
5	D 1135	May 26	200	2.5
7	D 1135	March	400	7.2
10	D 1135	June	600	22.3
12	D 1135	March	300	7.1
18	D 1135	February and March	900	25.6
19	D 1135	July	200	12.0
22	D 1135	June and July	1000	16.7
24	Uba	May	1000	0.0
25	D 1135	June	600	45.5
26	D 1135	March and August	800	16.1
28	D 1135	May, June, July and Sept.	1700	27.1
29	D 1135	August and September	800	34.6
30	D 1135	February, March and Aug.	1000	45.6
33	D 1135	August and September	1800	14.6
34	H 109	February and August	1500	48.0
35	H 109	July	800	18.6
36	D 1135	March	900	22.0
37	D 1135	February	500	47.2
38	D 1135	September	600	35.1
D	D 1135	May	100	20.0
	Total and Averages		15,900	22.7

Paauhau Sugar Plantation Company

Field	Variety	Dates of Examination	Total No. Canes Examined	Average per Cent of Canes Borer Injured
1	H 109	April	1000	18.6
17	D 1135	April	2500	4.8
6-a	Yellow Caledonia	April	1000	14.3
	Total and Averages		4500	12.5

Hakalau Plantation Company

Field	Variety	Dates of Examination	Total No. Canes Examined	Average per Cent of Canes Borer Injured
2	Yellow Caledonia	August	6000	16.8

TABLE 2

Parasitism of the Cane Borer (*R. obscura*) by the Tachinid Fly (*C. sphenophori*) at Paauhau Sugar Plantation Company, 1924

Field	Date of Examination	Number Canes Examined	No. Parasitized Borer Larvae Present	No. Groups Fly Pupae Present	No. Groups Empty Fly Puparia Present	No. Unparasitized Borer Larvae Present	No. Borer Pupae Present	No. Borer Beetles Emerged	Parasitism based on All Forms, Including Larvae	True Parasitism Columns 5, 6, 8, 9	Remarks
1	Sept.	511	73	82	386	295	116	330	42.2	51.2	Mixed D 1135-Yellow Cal. and H 109, rat. 18 to 19 months old at time of examination.
	Oct.	514	55	52	296	645	98	386	26.3	41.8	
Field 1 Totals		1025	128	134	682	940	214	716	33.5	46.7	
2	June	1759	125	111	440	552	191	635	32.4	40.8	Mixed D 1135-Yellow Cal. and H 109, rat. 18 to 19 months old at time of examination.
	Aug.	105	12	15	26	149	64	65	16.0	24.1	
	Sept.	155	8	18	44	119	74	104	19.0	25.8	
Field 2 Totals		2019	145	144	510	820	329	804	29.0	36.5	
2A	Mar.	162	3	5	57	59	23	59	31.0	43.0	H 109, rat. 16 months old at time of examination.
7	Feb.	200	6	3	62	55	27	61	33.4	42.4	Yellow Caledonia. Long ratoons.
	Mar.	472	11	22	181	96	53	85	47.6	59.5	
	April	507	11	17	237	246	130	233	30.1	41.1	
	May	312	14	21	127	97	58	118	37.2	45.6	
Field 7 Totals		1491	42	63	607	494	268	497	36.0	46.6	
14	April	400	4	21	117	104	58	94	35.6	47.5	Yellow Caledonia and H 109. Long ratoons.
	May	470	37	64	164	102	137	279	33.8	35.4	
Field 14 Totals		870	41	85	281	206	195	373	34.4	39.1	
15½	Feb.	90	0	2	32	12	21	13	42.5	50.0	D 1135. Long ratoons.
	Mar.	90	1	0	36	19	5	16	47.3	63.1	
Field 15½ Totals		180	1	2	68	31	26	29	45.2	56.0	

Note: In the June examinations of Field 2, 164 canes were examined by Mr. Elliott at Paauhau Sugar Plantation Company.

Most of the cane of Table 2 lying below 900 feet elevation.

TABLE 3

Seasonal Activity of Borer Parasite *C. sphenophori*

Month, 1924	No. Parasite Larvae and Pupae Found	No. Empty Parasite Puparia Found	Percentage of Developing to Emerged Parasites Found
February	11	94	10.4
March	42	294	13.2
April	53	354	13.0
May	136	291	31.8
June	236	440	34.9
August	27	26	50.9
September	181	430	29.6
October	107	296	26.5

TABLE 4

Parasitism of Cane Borer in Top, Middle, First 3 Feet and Bottom of Cane Stalk. Borer Larvae Included in Calculation.

Top of Stalk			Middle of Stalk			First 3 Feet of Stalk			Bottom of Stalk		
Parasitized........	Not Parasitized.....	Per Cent Parasitism..	Parasitized........	Not Parasitized.....	Per Cent Parasitism..	Parasitized........	Not Parasitized.....	Per Cent Parasitism..	Parasitized........	Not Parasitized.....	Per Cent Parasitism..
546	1239	30.5	811	1304	38.3	1005	1843	35.2	636	1697	27.2
Actual Parasitism by Section Borer Larvae Excluded in Calculation											
481	705	40.5	633	752	45.7	913	995	47.8	611	1081	36.1

TABLE 5

Part of Stalk Attacked by Borer—All Fields Combined

Number of Borer Channels in 5,819 Injured Stalks

Top	Middle	First 3 Feet Above Bottom	Bottom 1 Foot
1945	2622	3688	3449

TABLE 6*

Cane Borer Parasitism on Maui, Oahu and Kauai

Locality	Dates of Examination 1924	No. Groups of Fly Pupae or Puparia	No. Beetles Emerged Plus Beetle Pupae	Percentage of Parasitism
Experiment Station, H. S. P. A.	March 7-15	326	198	62.2
Experiment Station, H. S. P. A.	April 9-10	375	165	69.4
Experiment Station, H. S. P. A.	May 2-8	238	368	39.2
Experiment Station, H. S. P. A.	October 14	44	13	77.1
Experiment Station, H. S. P. A.	December 19	80	75	51.6
Pioneer Mill Company, Ltd.	March 18	6	35	14.6
Pioneer Mill Company, Ltd.	March 18	38	13	74.5
Pioneer Mill Company, Ltd.	March 18	3	5	37.5
Wailuku Sugar Company	March 20	17	52	24.6
Wailuku Sugar Company	March 20	41	93	30.5
Kaeleku Sugar Company, Ltd.	March 21	30	7	81.0
Maui Agricultural Co., Ltd.	March 25	17	28	37.7
Olowalu Company	March 26	12	23	34.2
Hawaiian Commercial & Sugar Co.	March 26	2	13	13.3
Hawaiian Commercial & Sugar Co.	March 26	7	10	41.1
Waipio, Oahu	April 29	41	19	68.3
Koloa Sugar Company	July 12	68	22	75.5
Kahuku Plantation Company	Jan. 2, 1925	27	31	46.5
Kahuku Plantation Company	Jan. 2, 1925	10	8	55.5
Kahuku Plantation Company	Jan. 2, 1925	25	45	35.7
		1407	1223	46.5

Progress of the Raw Sugar Industry†

By W. van H. Duker

Soon after your Chairman had requested me to report to you on the "Progress of the Raw Sugar Industry," I realized that, in order to do so, we must first agree upon what we understand by progress; in other words, we must have a standard with which to measure progress. This, in itself, is not quite so simple, but, in answer to a request made to several prominent men engaged in the sugar industry for a definition of what constitutes progress in the sugar industry, I think Mr. Herbert Walker gave one most to the point when he considers progress "the ratio between service rendered and energy expended," to which he modestly added that he preferred to leave the development of the ratio to others. Again, we may consider that the industry makes progress the nearer it fulfills its object as a commercial enterprise.

* Data secured by Mr. O. H. Swezey.

† Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

At the annual convention of the United States Chamber of Commerce, the following definition was agreed upon as the object of business: "The function of business is to provide for the material needs of mankind, to increase the wealth of the world and the value and happiness of human life."

However, to keep our feet on the ground and to write a report acceptable to this convention, I decided to confine myself more particularly to the technical development of the raw sugar industry of Hawaii, to facts and figures relating thereto, the causes of its development and the possibilities of its continuance. Thirty-three years ago the world's sugar production was 6,000,000 tons:

Cuba's production was	675,000	tons
Java's production was	360,000	"
Philippines' production was	160,000	"
Hawaii's production was	130,000	"

For the crop 1923-1924 (the nearest estimate at this time) the world's sugar production is 20,000,000 tons.

Cuba's sugar production is	4.200,000	tons
Java's sugar production is	1,830,000	"
Philippines' sugar production is	525,000	"
Hawaii's sugar production is	678,000	"

In addition to this, I submit the following statistics, while I would venture to remind those who doubt if we make progress at all, that a developing industry has much in common with that of a human life; a child's weight and height double themselves every six months, year, two or three years in the first years of its life, while an adult stops growing or grows so slowly as to be hardly aware that he is doing so. Would you deduce from this that a boy of six years of age is superior to a man of forty?

Production of sugar by islands in periods of 10 years each:

	Hawaii	Maui	Oahu	Kauai
1894-1904	1,120,524 tons	478,188 tons	563,083 tons	576,623 tons
1904-1914	1,643,021 "	1,195,807 "	1,259,294 "	874,077 "
1914-1924	2,059,257 "	1,362,645 "	1,417,560 "	1,093,251 "

Totals for the Group

1894-1904	2,738,418	tons
1904-1914	4,945,199	"
1914-1924	5,932,715	"

In analyzing what has caused this rapid development, we find that cooperation of capital and science are the very foundation. As early as 1883 the sugar planters combined in their effort to secure suitable labor supply, which combination later developed into the Hawaiian Sugar Planters' Association with its many and ever increasing number of fields of activity.

In 1895, the Experiment Station was organized and from that time on dates the more tangible development of the technical side of the industry. Studying the past records, we find a worthy list of inventions to the credit of progressively spirited local sugar men who have in no small measure been instrumental in making the industry what it is today.

Of the many locally developed labor saving devices and improvements of manufacturing machinery which have lasted through the years and have proven their worth, we have:

1. Weston Centrifugal, 1855, by D. M. Weston, Manager, Honolulu Iron Works Company.
2. Juice Strainer, Cush Cush Elevator and Automatic Bagasse Feeder, 1895, by John A. Scott, Manager, Hilo Sugar Company.
3. Wick's Cane Unloader, 1901, A. Wick, Chief Engineer, Honokaa Sugar Company.
4. Rotary Bagasse-Feeder, 1904, Max Lorenz, Consulting Engineer, H. Hackfeld & Company.
5. Clarifying Centrifugal, 1909, E. W. Kopke, Consulting Engineer, Honolulu Iron Works Company.
6. Messchaert Juice Grooves, 1913, P. A. Messchaert, Superintendent, Oahu Sugar Company, Ltd.
7. Searby Shredder, 1914, Wm. Searby, Superintendent, Hawaiian Commercial & Sugar Company.
8. Ewart Bagasse Conveyor, 1916, A. F. Ewart, Works Manager, Honolulu Iron Works Company.
9. Ramsay Maceration Scraper, 1916, W. A. Ramsay, Manager, Catton, Neill & Company.
10. H. I. W. Company, Patented Steel Check, 1916, W. G. Dyer and A. F. Ewart, Engineers, Honolulu Iron Works Company.
11. Foster Motor Fuel, 1917, J. P. Foster, Superintendent, Maui Agricultural Company, Ltd.
12. Meinicke Chutes, 1921, J. Meinicke, Chief Engineer, Maui Agricultural Company, Ltd.
13. Peck's Revolving Juice Screen, 1922, S. S. Peck, Consulting Chemist, Alexander & Baldwin, Ltd.
14. Cast Steel Top-Cap with Hydraulic Jack Incorporated, 1911, W. G. Hall, Manager, Honolulu Iron Works Company.

The Chemical Division of this Association is, of course, primarily interested in the question of recovering the largest quantity of sugar out of the cane at the lowest possible cost.

Taking as a basis the average per cent sucrose recovery for the period of the years 1909 to and including 1913, we find this at 85.46 per cent (85.4698). The average total recovery of sucrose during the period of the next ten years is 87.558 per cent.

During the period (1914 to 1923) 6,545,297 tons sucrose were delivered in the cane to the factories. If the percentage sucrose recovery had remained at the average figure for the five years 1909-1913, 5,791,151 tons sugar (at 96.6 Pol.)

would have been the output. Due to the application of technical knowledge and the improvement of equipment, 5,932,715 tons sugar at 96.6 Pol. were marketed or 141,564 tons *more*. At as moderate a valuation as $75.00 per ton this has meant an additional $10,617,300 for the ten years.

Two factors have been at work to make such an accomplishment possible; first of all, the period of increased efficiency and standardization, which period I should like to call the Gartley period, since he was the man who succeeded in arousing the necessary interest and enthusiasm; and, secondly, the exchange of mill data and the annual synopsis thereof. To those who depend in their judgment upon information contained in these data, this synopsis or study of factory accomplishment is of the greatest value.

I hope that at this meeting some details of this synopsis as well as some desirable alterations and additions to the weekly report of Comparative Mill Data will come up for discussion. These reports are extensively used and its publication eagerly awaited by the ambitious engineers and factory superintendents. If, in addition to the data now already published, a figure could be included giving, weekly or monthly, the percentage total sucrose recovery to date for each factory, in order to draw more attention to this figure and less to the extraction data, which, after all, is only an intermediate figure often wrongly taken for total output or yield, its value would be materially increased.

As an illustration of what has been accomplished in a group of factories, not so much by any radical change of equipment but by a systematic and sustained effort of the plantation management in cooperation with those immediately in charge of operation, I quote the following:

Factory Losses Expressed in Per Cent Sucrose Recovered on Sucrose in Cane

	Waiakea Mill Co.	Laupahoehoe Sugar Co.	Kaiwiki Sugar Co., Ltd.	Hamakua Mill Co.	Honokaa Sugar Co.
1920	82.8	88.3	85.9	79.0	84.5
1921	83.6	86.3	85.7	78.6	81.6
1922	85.3	87.4	86.0	80.3	85.3
1923	86.6	87.7	86.5	86.2	86.6
1924	86.8	88.2	87.2	86.7	87.4

	Niulii Mill & Plantation	Halawa Plantation, Ltd.	Union Mill Co.
1920	74.0	76.5	77.3
1921	80.0	71.7	74.4
1922	81.8	78.0	80.0
1923	81.8	78.8	82.6
1924	82.6	83.7	83.2

However, great and remarkable as the technical development of our industry has been in the past twenty years, I believe that from now on our greatest gain must come from a further improvement in the quality of the cane as we receive it at the mills, since our records show clearly that no factory improvement is able to recover the losses due to deterioration of the raw material itself and I heartily agree with the statement of Mr. J. P. Foster, of Paia, that the future

development depends on our success in learning more about the quality of the impurities and in overcoming its influence on the yield.

In a broad sense, the development of the sugar industry is practically unlimited. The consumption of sugar in the United States in 1922 was 112 lbs. per capita. In 1900, it was 70 lbs. In Europe, the per capita consumption is less but up to the outbreak of the war it was increasing rapidly and the increase is certain to be resumed as pre-war conditions are reestablished. The world's supply of sugar for the year 1924 is estimated at 20 million tons. The consumption will about equal this supply, but if the per capita consumption of the world's total population were equal to that of the United States 80 million tons would be required to supply the demand.

According to evolutionists, it took millions of years to form a tadpole and other millions of years before the tadpole dropped its tail and crawled out to live on land. Growth is slow. This is one scientific principle that has never been disputed, though it is little recognized in the modern world.

Great problems are immediately ahead of us, well worth the study and thought of everyone connected with the technical development of the industry. Eliminating the refinery operations and making refined sugar direct from the cane is one of them; recovering the sucrose now lost in our final molasses and amounting to from 6 to 8 per cent of the total supplied to us by nature is another.

Sugar Cane Breeding at Coimbatore, India*

By T. S. Venkatraman †

Introduction

Leaving out of account for the time sporadic, often unauthenticated and generally unsuccessful attempts at growing sugar cane from seed, the first success in this direction in India was achieved in the year 1911 by Dr. C. A. Barber, C. I. E.[1]

This led to the foundation at Coimbatore of a sugar cane-breeding station for the whole of India with the definite object of improving the quality of the indigenous Indian canes. The very poor quality of these canes—some of them the poorest specimens of cane in the world—is one of the main reasons for the very low acre yields obtaining in India. The low yields render it necessary for India to import from outside, annually, refined sugar valued in most years at over fifteen crores of rupees or ten million sterling in spite of her possessing within her own confines nearly half the world area under sugar canes.

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* Presented in part at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

† Government Sugar Cane Expert, Coimbatore, India.

In view of the increasing attention that, in recent years, is rightly being given to the breeding of sugar canes in various parts of the world, it is thought it might be of some use to briefly sketch in this note certain details of the technique as adopted at the Coimbatore station. This increased attention is not a little due to the outbreak in certain localities of new, little understood and serious diseases of the cane crop. Certain noticed differences between the Indian work and that done elsewhere, together with the apprehension that the Indian work is but little known outside as judged from references in published papers, have been additional inducements for writing this note.

Need for Careful Study of Parents

While the wide diversity of forms from a variety even when self-pollinated, is easily the first observation that strikes a sugar cane breeder as he starts his work, a certain similarity in the seedlings obtained from the same parent soon forces itself on his attention as the work extends. The indigenous Indian canes are of a type quite distinct from the tropical kinds and striking differences between the seedlings raised from each class soon revealed themselves. It was further found that subtle, but none the less appreciable differences, separated batches of seedlings obtained from even allied parents.

It was found that the tropical canes generally yielded types unsuitable for introduction into Northern India with its short growing season for cane and the rigours of winter, frosts not being uncommon in certain localities; and over 80 per cent of the Indian cane area is situated in such tracts. On the other hand, the seedlings from the only group of Indian canes which freely set seed proved to be no improvements on the parents; the bulk of these suggested going back in the direction of the wild *Saccharums*.

Attention was, therefore, early turned to the raising of crosses between the hardy Indian canes and the rich tropical kinds as the most promising line of work for the station. This line has proved so fruitful of practical results that, in recent years, all the lakh or lakh and a half of seedlings raised each year have been obtained after definite and often complicated cross pollinations.

Realizing that the conditions of growth for cane in Northern India are far from satisfactory, an early collection of the wild *Saccharums* was made with a view to use them as parents and their field characters carefully studied. This day some of the most useful seedling canes, already introduced into cultivation in North India contain the wild blood in one or more of their grand or great-grandparents; and, it is believed, that their success under the trying conditions is largely due to this parentage. Though more than one wild *Saccharum* was used in the cross pollinations, *Saccharum spontaneum* alone has been found of value.

For designing cross-pollination operations one of the first essentials is a knowledge of the type of seedlings each parent gives rise to. Consequently, every variety that happened to arrow had its flowers collected—if possible after selfing—seeds sown and the characteristics of the resultant population recorded. The data, so far collected, though far from being accurate for drawing definite conclusions as to the inheritance of characters in the sugar cane are of considerable practical use in designing the crossings. Inherent difficulties in the work have so far prevented the elucidation of any laws in the matter of inheritance.

It has been found for instance, that vigor and hardiness could be induced in a population by crossing with *Saccharum spontaneum;* that such crossing appreciably lowers the sucrose and purity in juice; that short but erect seedlings are obtained from mating with Mauritius seedling No. 1237; that increase in sugar contents could be secured by using Barbados 208, Vellai, B. 3412, P. O. J. 100 and Co. 214; that one should be prepared for considerable amount of bad habit and spotting of leaves if any of the members of the Indian group of Saretha canes are used as parents; that early maturity could be induced by using Co. 214, D. 74 and 100 P. O. J., and that late maturity generally results from using *Saccharum spontaneum.*

Selfing and Use of Cloth Bags in Sugar Cane Breeding

The Coimbatore experience in the matter of selfing is rather limited as it was early found that this line of work was not likely to be of use in the solution of the Indian problem. Enclosing sugar cane flowers inside cloth bags either for selfing or for protecting the artificially cross pollinated arrows from other undesired pollen had also soon to be given up as serious defects were noticed.

Firstly, the bagging was found to have an adverse influence on the seeding of the enclosed arrow attributable apparently to the rather unnatural conditions obtaining inside of the bags; the temperature inside of the bags was found to be higher than that outside, sometimes, by as many as ten degrees.[2]

Secondly, it was found that cloth of even fine texture did allow a certain amount of pollen to pass through its meshes. On more than one occasion arrows carefully bagged showed in the resultant seedlings unmistakable indications of foreign pollen. One rather remarkable instance of the kind was the rather free germination of an arrow enclosed in muslin, the arrow not possessing any fertile pollen of its own. In this instance the seedlings obtained showed on germination unmistakable signs of the blood of a wild cane flowering in close vicinity.

Certain observations made while extensive bagging was in practice are here recorded. The bags in the field need constant and careful supervision to prevent entry into them of rats and squirrels which often find in them a snug abode for themselves and their little ones. The rather warm fuzz comes in handy for nesting and bedding. Secondly, the bags are best held firmly in their position by planting the main supporting bamboo on the windward side and further fastening the bag to a shorter bamboo planted on the opposite side. Thirdly, the bags require constant lifting up and adjustment to prevent the vigorously growing arrow from touching the bags at the top and incidentally exposing the stigmas to pollination from outside through the meshes of the bag. Fourthly, in the event of rain the arrows soon develop fungoid growths, doubtless due to the warm and humid conditions prevailing inside the bags and need to be collected as quickly as possible after they are ready. Fifthly, the bags need inside of them some kind of frame work to stretch them out and not allow the cloth to touch the arrows inside of them. Both iron and bamboo frame works were used; the latter are preferable as they keep the bags cooler.

Cross-Pollination in the Sugar Cane[3]

As already mentioned the bulk of the seedlings at Coimbatore have been obtained through cross-pollination. The more important of the methods employed are briefly described below mentioning the advantages or disadvantages associated with each.

(1) *Emasculation*: After trial for two years emasculation had to be given up as unsuitable because of (a) the extreme delicacy of the floral parts, even a violent bending of the axis sometimes prejudicially affecting the seeding of the arrow, (b) the minuteness of the parts necessitating the operations being done under a high magnifying lens, (c) the inconvenient height at which the operations have to be carried in the field, heights of fifteen feet from the ground not being uncommon and (d) the slowness and the paucity of results, a large number of the operated flowers withering away from the handling. If anything, it was particularly unsuited to the Coimbatore station which, in the first instance, was sanctioned experimentally for a period of five years.

(2) *Bagging Together Arrows of the Two Parents*: This consisted of bringing together inside the same cloth bag arrows of the two parents and trust to the crossing taking place inside of the bags. The method was found to possess serious defects. Firstly, it was not always possible to bring the desired arrows into the same bag however close the varieties may have been designedly planted in the first instance. Secondly, it was found that the juxtaposed plants sometimes either did not arrow at all or arrowed at different dates. Thirdly, the arrows often came out at different heights rendering their being bagged together very difficult, if not impossible.

(3) *Placing Inside the Bag Each Day an Arrow of the Pollinating Parent*: The arrow which it is desired to use for pollination is cut the previous evening, the bottom of the stalk stuck into a bottle containing water and hung up inside the bag a little above the enclosed arrow. Next morning the anthers protrude, liberate the pollen and cross-pollination is secured. The liberation of the pollen is sometimes facilitated by an operator going round the next morning and gently tapping the arrow at the right time. The pollinating arrow has to be cut at a stage when it is likely to yield the maximum amount of pollen on the succeeding day, i. e., when the anther protrusion in the arrow, which is generally from top downwards, is within one-third from the top. Sometime after the pollination the arrow has to be removed from the bag to avoid its seeds getting mixed with those of the pollinated arrow. In this method each day and for each pollination one arrow of the father has to be sacrificed. The operation has to be repeated from three to four days to ensure a satisfactory pollination of the bulk of the stigmas in the mother arrow. The method has proved very satisfactory apparently because the pollen remains in its own receptacle till actually liberated when it falls directly on the stigmas. The method has been in use at Coimbatore from the year 1912.

(4) *Dusting the Mother Arrow with Collected Pollen:* This consists in surrounding the father arrow with a tissue paper bag sometime before anther protrusion, gathering the pollen immediately after anther dehiscence and dusting the pollen over the mother arrow. The pollen has to be used almost im-

mediately after collection because it quickly loses vitality; this greatly limits the number of cross-pollinations that can be effected on a particular day. The method does not lend itself to the effecting of a large number of different cross-pollinations except with a correspondingly large number of operators. It has one advantage over the method previously described in that the arrows of the pollinating parent need not be destroyed and hence are available for pollen collection from three to four days. In this method also the pollinations have to be repeated three to four days to ensure a dusting of the bulk of the stigmas.

For sometime blowing the collected pollen on to the stigmas by means of a "blowing ball" was attempted, the pollen being kept in gelatine capsules.[4] Great economy of pollen resulted therefrom but the inevitable handling associated with it has thrown it rather into disfavour in recent years.

(5) *Dusting the Mother Arrow with Pollen Preserved Largely in Its Own Anther-Sacs:* In this method such branches of the pollinating arrow as are likely to protrude their anthers during the day are scissored off fairly early in the morning and well before anther protrusion in the arrow. Ability to pick out such branches comes easily with a certain amount of experience. The branches are now wrapped loosely in tissue paper, each paper packet containing a few of the branches. The paper packets are now stored in small bamboo baskets very much like the ones used for storing and transporting fruits and vegetables, i. e., baskets with plenty of air holes in them. Care is taken to see that in a basket the packets of only one variety are stored; this is done to avoid mixtures. The baskets are now stored until needed in the cool shade of the sugar cane plants. When the mother arrow is ready for pollination the basket with the paper packets is taken to the place, one of the paper packets gently unwrapped and the arrow branches shaken over the stigmas it is intended to cross-pollinate. If during the operation a perceptible pollen cloud is not noticed the second packet is taken out of the basket and is similarly dealt with. The chief advantage of the method consists in the fact that inside the paper packets the pollen continues viable for a longer period than otherwise, sometimes by two hours. This prolonged viability has been established both by artificial germination of the grains and also from the seed setting of the arrow after the operation. It has been found that, even if the anthers do open inside the paper packets, the pollen largely remains in the sacs and is mostly liberated only as the branches are shaken over the stigmas. This is the method now largely in vogue and has been found the most satisfactory, so far, in efficiency, economy of pollen employed and economy in the number of operators that are needed for effecting the same day a large number of cross-pollinations.

Use of Bags in Cross-Pollinations

In view of the adverse effect on seed setting and the other defects connected with the use of cloth bags already mentioned, experiments were made leaving the cross-pollinated arrows unbagged and the results obtained appear to be satisfactory. It has been found that, so long as the artificial cross-pollination is done at the right time and with plenty of the desired pollen of proved vitality, the results are by no means unsatisfactory. In such cases the desired

effect appears to be attained by the pollen employed getting a start over other wind-borne pollen that may reach the stigmas later. The efficiency of the pollination can be enhanced by surrounding the pollinated arrow with a paper cylinder at the time of dusting. The arrangement, by confining the pollen to a smaller cubic space round the arrow, secures a more efficient pollination.

It has to be admitted that unbagged crosses effected in the above manner will not furnish satisfactory material for a scientific study of the laws of inheritance in the sugar cane; but against this it has to be remembered that even cloth bagging does not absolutely rule out access to outside pollen. In breeding work undertaken chiefly with the idea of rapidly achieving practical results the method has a wide sphere of usefulness.

Cross-Pollinating Varieties Rich in Own Pollen

For a long time it was the practice to artificially pollinate only such varieties as do not possess healthy pollen of their own; such varieties were chosen because of the impossibility of the collected seed including any selfed ones. The very varied needs of the station, however, rendered desirable to employ a wide circle of parents including those which possess healthy pollen of their own. Experience gained during the last half a dozen years has shown that the desired crosses with but very little chances of selfed seeds could be obtained even from the latter class of varieties by pollinating the mother arrow at the right time and with plenty of the intended pollen well before the dehiscence of its own anthers. In these cases the desired result appears to be obtained from the dusted pollen getting a good start over any self pollen that may reach the stigmas later.

The crossing done at Coimbatore has mostly been between tropical canes used as mothers and the hardy Indian canes. The anthers of the former class, generally, open much later in the day than those of the latter class; a difference of two hours has been noticed in certain cases. This fact has greatly facilitated the pollination described in the previous paragraph.

Pollen Viability Tests

In all such work it is important to test the pollen used for viability at each stage. In the earlier years a great deal of time and energy was wasted owing to the non-availability of a reliable test for viability. In the year 1920, however, a satisfactory test was discovered.[5] The pollen, it is desired to test, is sown on live stigmas of *Datura fastuosa*, when viable pollen quickly germinates. Other workers have used the stigmas of the tobacco plant for the purpose.[7] Frequent tests for viability are very important in the sugar cane because of the rapidity with which it loses viability.

Preservation of Cane Pollen by Controlling Anther Dehiscence[5]

It was often found that the two varieties, it is desired to cross with each other, arrowed in different places separated from each other by railway journeys of varying periods. Experiments undertaken for preserving pollen during transport have yielded a fairly satisfactory method. The method essentially con-

sists in preventing the anthers from protrusion and dehiscence by creating humid conditions around the sugar cane arrow during transport. So far it has been possible to preserve pollen in this manner for about ten days.

A striking use of this method in a rather difficult cross-pollination is described below. It was desired to effect a cross between *Saccharum spontaneum* as mother and a tropical cane "Karun" as father; but this was rendered difficult from the fact that the anthers of the former open much earlier than those of the latter, the approximate timings being respectively 6 a. m. and 8:30 a. m. By preserving the arrows of "Karun" in a special crate the above cross has since been successfully accomplished. The resultant seedlings now growing at the station show, in some of them, unmistakable traces of Karun blood.

Test for Pistil Fertility[6]

For a long time past the presence of starch inside the cells of the style branches has been used as a sign of pistil fertility. The test has enabled the raising of crossed seedlings with a high degree of certainty as to results. Other workers, however, have not found the test quite reliable. The correlation was, therefore, reexamined within the last two years, over 300 varieties and seedlings being subjected to the test. It has been found that, wheras it is a test of considerable value in the Indian varieties, it does not work satisfactorily in the tropical canes and breaks down in the case of new seedlings. This is of some interest and needs further investigation.

Value of Special "Arrowing" Plots in Sugar Cane-Breeding

It has been found a great advantage to plant what in the station are termed "arrowing" plots for carrying on the cross-pollination work. These are special plots laid out away from the main fields and are sometimes situated under different conditions. They are also sown often at a different time from the main plots. Certain of the advantages derived from them are here mentioned. Firstly, as varieties differ considerably in their value as parents, the special plots enable the growing of a large number of plants of the most desirable parents. Secondly, canes intended for arrowing sometimes need a treatment different from that for the main plots. It has been found that a vigorous growth in the early stages followed by a check, induced at Coimbatore by special ill treatment of the plants, is conducive to arrowing; the special plots enable such treatment being given. Thirdly, varieties in such plots frequently arrow at a time slightly different from those in the main fields, undoubtedly due to the difference in treatment. The slight differences in time of arrowing have often materially helped in the cross-pollination work. Indeed it would appear profitable to plant the useful parents under as many conditions of soil and irrigation as may be available at any station.

Collection and Storage of Sugar Cane Arrows for Sowing

The best stage to collect arrows for sowing is when the florets begin to separate from the top branches and drop off. Even arrows collected at a stage

as immature as to have the anther protrusion still in progress from the bottom branches have been known to germinate from the top branches; such seedlings generally turned out to be weak and showed a high degree of mortality.

In an arrow the largest number of fertile seeds are generally found in the top two thirds. Should there be rain the arrows need to be collected some little time after to allow their drying; arrows containing moisture quickly develop fungoid growth on storage.

Immediately after collection the arrows are loosely packed in tissue paper with full details written on a label placed inside of the packet and on the outside of the paper wrapper. Only a few arrows—not more than ten—are placed in each packet; this is done to allow a good aeration. These packets are dried in the sun for a couple of days to eliminate any moisture in them.

The packets are then taken to a closed room and the fluff collected on a sheet of tissue paper spread on the ground, the dislodgment being facilitated by tapping the arrow or gently passing the fingers down the arrow. In this operation the arrows are held over the paper, bottom upwards. The collected fluff is again wrapped loosely in tissue paper and labelled as before. The packets are not to be stored in great heaps or inside closed receptacles; they need plenty of ventilation and are best spread out on tables. The stored packets need protection against rats and ants. These are generally sown about two weeks after collection and, though definite experiments have not been made, the impression has been formed that if sown immediately after collection, the seedlings exhibit a higher mortality.

Germination and the Early Stages of Growth[8]

Sowing and Germination: For sowing, shallow, circular, country earthenware pans—12″ across at top, 9″ at bottom and 6″ high—have been found satisfactory. Previous to sowing the pans are numbered with some waterproof paint. Suitable provision having been made for free drainage at bottom, the pans are filled with a mixture of equal parts of well rotted horse dung and sand. The fluff is now laid in an even thin layer on the surface and the first watering done from a garden rose held 3 feet above the pans. The force of the impact gathers round the tiny seeds a small amount of soil and this facilitates germination. The quantity of water employed should not be such as to form a pool in the pan, as it leads to the seeds all getting to one side and germination is affected. Immediately after sowing, the pans are arranged in groups—each group containing all the pans of a particular lot—and each group is separately labelled with details as to variety sown, date of sowing and other details. For this purpose paper labels first written in pencil or Indian ink and subsequently dipped in melted paraffin wax have been found useful; they are unaffected by the frequent *watering*.[9] Germinations have not been noticed earlier than three days from sowing; and pans not germinating within a fortnight have rarely been found to do so later.

Watering: At Coimbatore, it has been found necessary to water the pans as often as three to four times during the day. The watering is always done through a garden rose. For proper germination it has been found necessary

to keep the fluff always moist. After germination the plants need much less water, as the roots quickly develop and traverse a good bit of soil. The young cane plants are often very susceptible to excess of water and quickly turn yellow.

Precautions During Early Stages: It has been found useful to place the seedling pans on raised bamboo platforms about 2½ to 3 feet from the ground. Besides facilitating constant inspection of the young plants the arrangement is of use against ants and crickets. It has been found best to place the seedlings in full sun. The young sugar cane plants appear to revel in full sun and are rather susceptible to any kind of shade. In one instance the circular shade from a coconut crown marked off a corresponding circle of weak and unhealthy plants in the pans placed under it.

Weeding and Thinning of Sown Pans: The appearance of a large number of grass seedlings, which in the earlier stages look much like those of the cane and hence are difficult to weed out, is a trouble of some importance. At Coimbatore, the two weeds chiefly met with in the pans are *Chloris barbata* and *Cynodon dactylon.* It was found that the number of these could be greatly minimized if the horse dung, which is apparently the chief source of infection, is pitted for a couple of months before use and periodically watered. The heat generated in the pits appears to cause the death of the grass seeds. As an additional precaution the filled pans are allowed to remain unsown from ten to twelve days and occasionally watered during the period. The grass seedlings that come up are pulled out and the pans are now ready for sugar cane growing. The very few grass seedlings that appear even after the above precautions are easily removed by trained laborers. Should the pans be found very crowded, and contain say more than two or three hundred seedlings, they need pricking after a fortnight into a second set of pans. If the germination is thinner the pans may be left till they are ready for planting in the first ground nursery.

The First Ground Nursery: Fields with a fair admixture of sand are chosen for this as well as for the second ground nursery. They are prepared as for an ordinary cane crop, except that the surface needs to be cultivated with extra care to secure a fine tilth. Raised beds are formed, each bed being two feet broad, four inches high and any convenient length, the last depending on the lay of the land. The beds are spaced two feet apart, the soil between adjacent beds being used for raising them. The space between the beds facilitates constant inspection of the young plants.

Seedlings are transplanted to this nursery after they have been a month in the earthenware pans and, as far as possible, with a little ball of earth round the roots. The seedlings are planted out in rows running along the breadth of the beds with a spacing of two and a half inches between rows and one inch between plants in the row. For marking the positions of the plants a bamboo framework with nails driven in at suitable distances has been found useful. The beds are watered immediately before and after the transplanting, the former to receive the seedlings and the latter to compact the soil round the roots.

Watering of the beds is done with a garden rose till the seedlings are well established, when irrigation from channels laid in between the beds can be started. It is desirable, however, to postpone the latter kind of irrigation till

the plants are strongly rooted. Seedlings that may get slightly dislodged during the waterings should be carefully placed in position and the soil round them compacted; this is necessary chiefly soon after the transplating.

When the seedlings are grown about four inches, a combined hoeing and earthing is given by drawing firmly a sharp piece of bamboo in between the rows. With this operation the soil automatically heaps itself a little on both sides of the seedling rows. No shade is raised over the plants. The plants are allowed to grow in this first ground nursery for about two months when they would be found to have grown to about nine to twelve inches. While planting into this nursery no selection is made; only the dead and the very meagre plants are left behind in the pans.

The Second Ground Nursery: Land for this nursery is prepared in the same manner as for the first. It is then marked into plots, each plot being ten feet wide and of any convenient length. Drains, irrigation channels and paths are formed as indicated in the plan. Each plot has an irrigation channel on one side of it and a drain on the other. Each drain serves the two plots on either side of it and the irrigation channel between two adjacent plots is separated by a path.

The plants in the first nursery are prepared for transplanting into the second by a rather drastic trimming of the leaves to compensate for the loss of roots during the uprooting and the transplating operations. With the help of a hand hoe shallow V-shaped grooves are cut into the ground along the width of the plots at a distance of eighteen inches from one another. The prepared plants with balls of earth round the roots are placed in these grooves six inches apart and slightly watered. The removal of plants from the first nursery with balls of earth round the roots is greatly facilitated by the condition of soil in that nursery and by the fact that the plants are in beds raised from the ground level; the latter easily enables an operator to work round the plants. The plants are placed in position in the rows by raising a ridge of soil all along the row. Immediately after the ridging a copious irrigation is given to the plot.

For satisfactory results it is essential that the irrigation in the second nursery should be gentle, copious and of a soaking nature. This is secured by irrigating at the same time ten to twelve rows in the plot and by handling more than one plot at the same time. Water is led into the irrigation channel of the plot right to the farthest and lowest end. As there are no bunds separating the irrigation channel from the trenches between the rows of canes water would first fill in the end rows. When ten to twelve rows are thus irrigated, a bund is placed across the channel and a second set of ten to twelve rows receive the water. These rapidly fill in when a second bund is placed across the channel and water turned onto a third set of rows. A plan is given indicating the manner in which the irrigation is done. In this irrigation, irrigation water never touches the stems or leaves of the seedlings as they are situated on raised ridges. The drain in between the plots is of considerable use for drawing off any excess of water in the trenches after rains or an irrigation. The irrigation above described consumes a fairly large amount of water but it appears to be necessary for a satisfactory and uniform growth of plants in the second nursery. At Coimbatore such irrigations are given about once a week.

No shade is raised over the seedlings in the second nursery; any shading only prolongs the life of the weaklings. When planting from the first to the second nursery no special elimination is attempted. It would appear to be rather risky to attempt any eliminations before the full growth in the second nursery; certain seedlings which were rather poorly in the first nursery have suddenly bucked up in the second and have since proved useful in the districts. Such sudden progress in growth of seedlings is often associated with a sudden and rapid multiplication of the roots at the time

Trouble from white ants is sometimes experienced in the first and the second nurseries. Use of partially decomposed manure, often containing half decomposed fibrous material, is a great attraction for the pest. Tar-emulsion has been found of use in fighting it. The emulsion is prepared by dissolving a pound of soap in the same weight of water, boiling it and adding gradually about a pound of coal-tar during the boiling. The emulsion can be kept for sometime and, when needed, is diluted with water to make a half to one per cent solution. One per cent solution of this emulsion kills soft leaved delicate weeds. The solution is applied to the trenches from a garden rose before an irrigation. The irrigation water as it sinks down carries the solution along with it and helps to keep out the pest. Another common pest is the shoot borer *Diatraea auricilia* and no satisfactory remedy has yet been found for this.

Plots for Testing

From the second nursery the seedlings go to the final plots for testing. Here they are grown for well over a year and their botanical, agricultural and chemical characters studied all through the period. It is only at the time of planting in the final plots that any real selection of the seedlings is practiced. The selection is made on a large number of characters, vigor, habit and tillering being the more important of them. Some idea of the extent to which natural and artificial eliminations are made from germination to final planting would be gained from the numbers for the 1923-24 batch of seedlings. Out of one lakh and thirty thousand seedlings that germinated about a lakh were planted in the first nursery; eighty thousand of them reached the second nursery and in the final plots it is expected to plant out about ten thousand for the full year test.

The planting in the final plots differs from the others in one important respect. Whereas in the latter the seedlings are moved more or less intact, the final plots are planted from sets obtained from the seedlings. The nearly six-month growth in the second nursery is generally sufficient for cane formation in the seedlings; seedlings that do not form canes within the period are, it is believed, not likely to be of use for the bulk of North India with its short growing season. The immaturity of the sets at time of planting does not appear to be any disadvantage. On the other hand, they germinate very readily and very few gaps are noticed in the final plots. There is yet another advantage in planting the final plots from sets instead of with the seedlings themselves. When, in the earlier years, the seedlings were transferred to the final plots almost intact it was noticed that they exhibited a rather abnormal vigor, i. e., a vigor not always maintained

when the seedlings were multiplied from sets later on. With set planting a more dependable vigor is available for observation at the time of selections. The importance of this will be realized when it is remembered that the subsequent multiplication of useful seedlings is entirely from sets.

The period from germination to final planting occupies about nine months. The cane arrowing season at Coimbatore is October-November. By beginning of January the seedlings would be germinating. They are moved into the first nursery January-February and into the second April-May. They grow in the second nursery till August-September when they are ready for planting into the final plot. They remain in these plots well over a year, i. e., till past next September. Coimbatore possesses two seasons for the planting of canes; one in wet lands about February and the second in garden lands July-August. The planting in the final plots is done about September, towards the end of the second planting season at Coimbatore.

The testing plots are planted as indicated in the plan. The seedlings are arranged in square blocks of one hundred and the parents, the grandparents and sometimes the standard canes also are planted at the extreme sides of the plots. Whenever the seedlings are studied or their juice chemically analyzed, the parents and others are also dealt with at the same time. As the main object of breeding is to obtain types which are definite improvement on the parents or the standard canes, the advantage of having them always near and growing under practically identical conditions is obvious. The manner in which the seedlings are numbered in the plots is indicated in the plan.

It was frequently noticed that the border plants of a cane plot—those adjoining a path, an irrigation channel or a drain—showed markedly greater vigor than those inside the plots. At the time of selection it was found difficult to decide, in the case of a border plant, how much of its vigor was due to its advantageous position in the matter of light, air and water. To render the conditions of growths in the plots more uniform the borders are planted with a row of some fodder grass or a standard cane. This is cut out immediately before the plot is taken up for the final studies with a view to selection.

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Entomological Work in South America September, 1922 - July, 1924

By Francis X. Williams

Object of the Work

The main purpose of the work was to secure natural enemies of the wire-worms, *Monocrepidius exsul* and *Simodactylus cinnamomeus*, that cause damage in some of the Hawaiian cane fields. Search was also made for further parasites which might attack the cane beetle-borer *Rhabdocnemis obscura*, and for such other beneficial insects as opportunity offered. In addition, some effort was made to collect seeds of trees which would be of use for reforestation purposes in Hawaii.

Countries Visited

Nearly nine months were spent in Ecuador exploring regions both east and west of the Andes, five months in British Guiana, and six months in Brazil. Furthermore, brief stoppages were incident to the journey at the transshipment points, Panama, Trinidad and Barbados.

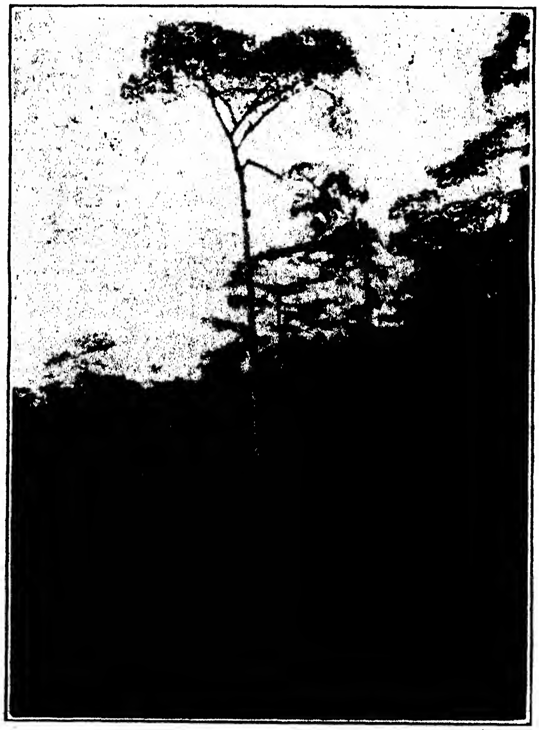
Itinerary and Investigations

On April 28, 1922, I returned from the Philippines, and on June 17, sailed for San Francisco. Following a vacation of some weeks in California I left for the East and after an interrupted trip arrived at Washington, D. C., on August 10. I remained there until August 30, employing my time mainly in the U. S. National Museum, looking over some of their extensive collections of Aculeate Hymenoptera and familiarizing myself with the larger Bethylid wasps, one species of which in the United States is known to prey upon the larva of a wireworm allied to our Hawaiian *Monocrepidius exsul.*

At the U. S. National Museum, as elsewhere throughout my travels, assistance in every way possible was extended me, and thanks are due to many individuals and institutions.

I embarked September 2, from New York for the Canal Zone on the United Fruit Company S. S. *Toloa.* After a layover of three days at Havana, Cuba, we

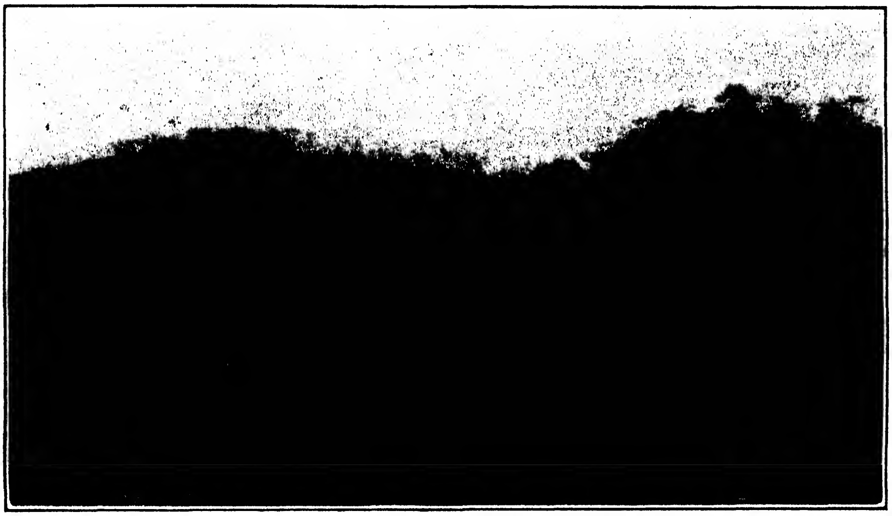
proceeded westward, reaching Cristobal, Panama, on the morning of September 12. At Ancon, on the Pacific side of the Isthmus, I met the U. S. Government Entomologist, Dr. James Zetek, and Mr. Molino, his assistant. On September 21, I left Panama for Ecuador on the Peruvian steamer *Mantaro,* which stopped for some hours at Buenaventura, on the Colombian coast and continuing the journey southward arrived at Guayaquil on September 26. This city has in the neighborhood of 90,000 inhabitants and is not, properly speaking, on the seacoast; to reach it one must travel miles up the extensive Gulf of Guayaquil and for a short distance along the Guayas River. Opposite the city this river is over a mile in width, though soon breaking up into several tributaries derived chiefly from the Andes, whose western crest is less than 100 miles distant. The more brackish lower part of the Guayas River is noted for its fine large "mangles" or Mangrove



Balsa' trees near Bucay, Ecuador. The wood is lighter than cork and much used in making rafts or "balsas."

trees, straight logs of which may be as much as fifty feet long, while in contrast to this heavy wood are rafts made of the lighter-than-cork "Balsa" tree, which flourishes a short distance inland and not infrequently yields sixty-foot timber. The chief product of Ecuador is cacao, with the ivory-nut for making buttons, etc., and fine hats, wrongly called "Panama" hats, holding an important place. Sugar is not manufactured in exportable quantities. Tobacco and rum are of some consequence.

Guayaquil is no longer a hotbed of yellow fever, but a healthy city. Rats are not encouraged in the municipality; the rat catcher may frequently be seen issuing from a building carrying his more or less filled wire traps, or some defunct rodents to the well-laden burro waiting outside. The garbage department as in many other places in tropical America, still has the assistance of numerous "Gallinazos," or black-headed vultures.



Forest during the dry season near Guayaquil, Ecuador. Conspicuous in this now comparatively leafless wood are leguminous and bignomiaceous trees. The seasonal aridity of the district is due in great measure to the proximity of the antarctic current, which so cools the atmosphere that it cannot condense over the hot lowlands.

I reached Guayaquil in the midst of the dry season, which though by no means universal throughout Ecuador is very marked about the city. The rains commencing suddenly in December convert the parched hills of mainly deciduous trees into masses of tropical verdure; and furthermore, they coax out of concealment innumerable "Grillos" or crickets into such conspicuous activity as to become a perfect plague for a few days, invading dining room and bedroom alike, alighting upon the headgear and shoulders of pedestrians, furnishing effective missiles for street gamins, and so flooding the brightly illuminated plazas that they must be swept up in heaps on the following morning. By the end of June dry conditions again prevail. Some little distance inland, however, the country is moister at any season; this is true at 90 kilometers, or about 56 miles along the Guayaquil and Quito Railroad, where the elevation is 1,000 feet. Ten kilometers farther the altitude is 1,850 feet, while beyond this the ascent of the Cordillera commences in earnest, for at Huigra at kilometer 117, amid stupendous fog-topped cliffs the altitude is 4,000 feet, though dryer conditions, emphasized by the presence of several species of cacti, spiny leguminous shrubs, and grasses, are evident. The Andes, at least in this part of Ecuador, are not well wooded for

their upper portions, as frequently is the case to the contrary in other countries of high mountains. On the lofty plateaux or higher mountain slopes the various herbs and shrubs often display handsome flowers. The paramo (11,000 feet up), a sort of upland desert, is characterized by certain plants, among which are curious compositae of gregarious habit, and by dreary areas of grass, or "pajonales." Finally the vegetation ceases and we may have exposed sand and cinders ("Arenales") up to the limits of perpetual snow, which in Ecuador is rather over 15,000 feet above sea level. There are sixteen or more perpetually snow-covered peaks in this country, the loftiest being Chimborazo, 20,496 feet, and Cotopaxi, 19,614 feet, usually considered the highest active volcano in the world.

The sugar cane industry in Ecuador is still in a very undeveloped condition. While there are several tolerably large plantations with mills for the manufacture of sugar, the more usual, small scattered areas planted to sugar cane are devoted very largely to the production of rum or "aguardiente," which potent beverage finds a ready sale, chiefly among the lower classes and the indigenes. In some instances, these rum factories appear tolerably up-to-date, with a water wheel for operating the mill, or oxen may be used for this purpose; in still other cases the affair may be simplicity itself—housed under a palm-thatched shed in the primeval forest, two hardwood logs serving as rollers and turned by means of wooden spokes (2 man power), a wooden catch-bowl beneath, and to one side, the distillery, consisting of a hollowed-out log with the necessarily tightly fitting cover, a sheet of crushed cane stems.

Considerable travel in sugar cane and other districts was done in Ecuador, and for making possible or facilitating these journeys, thanks are due to several gentlemen and particularly to the American Consul at Guayaquil, Dr. F. W. Goding, himself an enthusiastic entomologist. My first sugar cane pest investigations were made late in September at Ingenio Valdez, Milagro. This sugar estate, which is the most advanced in the country, is about an hour's train ride from Duran, across the river from Guayaquil. The mill is equipped with centrifugals and is fed from the cane fields by a plantation railroad. The extensive flat lands are planted chiefly to two varieties of cane, D 74, said to have been brought over from Louisiana, and "Nacional." The latter is a cane of nice appearance and whose tolerably soft stems are yellowish green and of good sugar content. It ratoons well and one is impressed by the large number of stems per stool and the well-developed root system. Harvesting was going on at the time, when a type of Louisiana cane loader was in action.

After the fields are cropped, the trash is disposed of by fire with the effect of driving out some of the fauna, consisting of lizards, rats and so forth, and which are forthwith attacked by the large birds of prey, constantly in the offing. The so-called Caracara "eagle" of ready cursorial ability as well as being a good flyer is one of the foremost of these feathered predators.

I recognized no cane diseases at Milagro, though not a few of the stems had split open disclosing the reddened interior. The most obvious sugar cane insects encountered here, as nearly everywhere else in cane countries of South America, were borers, of which a moth (*Diatraea?* sp.) and a weevil (*Metamasius*) were doing considerable damage. Of fifty harvested cane stems examined 74 per cent

showed borer injury. The young cane was at times badly damaged, presumably by the same moth larva, which killed the central shoot. A small weevil found as a larva and pupa worked rather close to the rind, but was not plentiful. Of leafminers, the larva of a small moth tunnelled near the leaf's edge. It was infrequent and was parasitized by a small wasp. Among insects with sucking mouth parts was a diaspine scale insect and the usual mealybug, besides a sparse and rather large Fulgorid leafhopper (*Bledina*). The ground was dry and hard and no wireworms were unearthed.

Bucay, my next stop inland, some fifty miles from Guayaquil, was visited October 4-11, 1922, and again June 2-5, 1923. I was put up at the house of the manager of the two rum factories; in one of these the crushing is done by a water wheel, in the other by oxen. The larger factory disgorges its fire-water into receptacles at the railroad by means of a pipe line several hundreds of feet in length. The sugar cane, which is of several varieties, is little attended to, apart from the replacing of gaps in its rows.

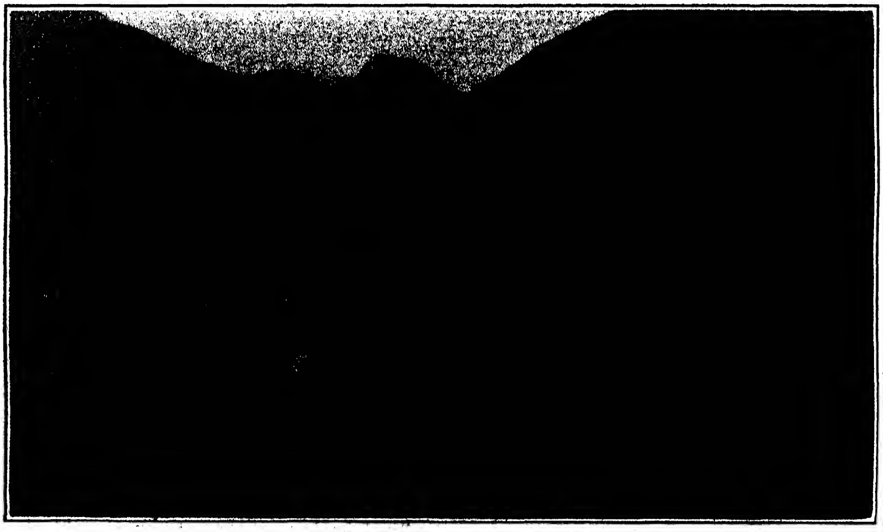
Insects are always abundant at Bucay since the moisture is usually sufficient to sustain them, and one notices the greater variety of butterflies as compared with those of some of the regions of the Far East. There was no difficulty in digging up several species of Elaterid wireworms in certain cane fields and in the grass lands adjoining, but none of their parasites was found. The beetles were likewise abundant and I saw here for the first time the brilliantly luminous "Cucuyo" beetle (*Pyrophorus* sp.), an insect allied to, though larger than *Monocrepidius* of Hawaii. Children strive to attract these "Cucuyos" by whistling, and waving a firebrand at them. What are known as false wireworms, and belonging to the beetle family Tenebrionidae could be scraped up under debris, such as flattened and decayed grass, and one of these larvae was found with a wasp grub on its underside, doubtless the young of one of the Bethylid wasps not uncommon about the cane fields. A common Bethylidae with a red-tipped abdomen was tried on true wireworms, but would not attack them. White grubs were not found in troublesome numbers, and one which was unearthed proved to be parasitized by a wasp grub, probably that of a *Tiphia,* clinging to the back of the second and third segments of the thorax. The cane stems were bored by a weevil larva, as at Milagro, but the insect was far more abundant in defunct banana stems nearby. The sugar cane mealybug found in one patch of cane was preyed upon by two species of ladybeetles (Coccinellidae). The larva of the rarer of the two was covered with waxy white processes, while that of the commoner was naked brown. Froghoppers or spittle insects (Cercopidae) of one species were not infrequent, breeding on the sugar cane stems. Only the young are enveloped in a frothy white mass in among the leaves, or between a leaf and the stem. The adults sometimes two or three per stem, were well wedged in at leaf bases. What seems to be the more injurious species of these insects, however, as occur in Trinidad, parts of Brazil, and in other places, feed, at least as young, largely on the superficial roots of the plant. Many leafhoppers were seen resting in weedy cane, though none seemed definitely attached to it.

Sucking at decaying cane stubs one occasionally flushes the very brilliantly metallic blue *Morpho,* an insect of considerable expanse of wing, and probably the most vivid and popularly known butterfly of tropical America. The wings

of these insects are much employed in decorative art, such as in glass-bottom trays, etc.

I found red mites or spiders attached to many kinds of insects in Ecuador and in greater numbers than observed elsewhere. This is true also of certain entomophagous fungi in the Neotropics, many *Cordyceps* (?) species developing fantastically on wasps, beetles, moths, leafhoppers, caterpillars and other forms.

The next move was to Naranjapata 100 kilometers along the Guayaquil and Quito Railroad, the place being marked by the railway station, a few laborers' cabins and a water tank. Entertainment was furnished after bedtime in the station master's office by the antics along the walls and ceiling, of the numerous white-bellied rats. At Naranjapata, as at Bucay, are banana plantations which have an interesting though unwelcome insect fauna. First of all, a huge, dark colored moth of the family Castniidae, in the larval stages attacks the stem of the plant, and judging from the size of the boring caterpillar one might well suffice to destroy a small plant. A second and smaller species, the widely distributed *Castnia licus,* also attacks the banana stem as well as that of the sugar cane. Orchids also suffer from the larvae of Castniidae. Dead or unhealthy banana plants are infested by the cane beetle borer of the region and by what seems to be another though closely related species, which tunneling often very profoundly into the watery pulp appears free from parasites, although preyed upon to some extent by the larva of a histerid beetle, itself not adverse to the semi-aquatic conditions of the stem. A fine butterfly, *Caligo* species, with a wing expanse of 6 to 8 inches, produces a docile brown larva several inches long that feeds on the banana leaf. Other species of *Caligo* sometimes attack sugar cane; a smaller yet still rather large butterfly, *Opsiphanes* by name, is also a banana



A portion of the village of Baños at 6,000 feet in the Ecuadorean Andes. In the left foreground is a patch of sugar cane; behind and above it on the hillside a 300-foot waterfall; to the right is Badcum Valley, with the cloud-wrapped Tunguragua volcano at its head. The tall and very slender trees chiefly to the right are native willows and a species of poplar.

feeder. At least *Caligo,* and probably *Opsiphanes,* are nocturnal or nearly so. The larva of a small bagworm moth with its mealy white banjo-shaped case is not uncommon on the plant and appears to feed on the fine powdery bloom of the stem and leaves.

Towards the end of my stay in Ecuador, a few days (May 30-June 2, 1923) were spent at Huigra at 4000 feet on the Pacific side of the mountain slopes. Nothing of note was found there.

Over a month—in two installments (October 25-November 5, 1922 and December 27, 1922-January 22, 1923) was passed at Baños, high up upon the eastern shoulder of the Andes. This interesting old village is situated upon an ancient lava deposit in the narrow valley of the Rio Pastasa, a wild and dangerous stream that finally works its way into the upper Amazon. The elevation is here about 6,000 feet and one has but to wander to the edge of town to view the fine snow-covered Tunguragua volcano rising to a height of between 16,000 and 17,000 feet. This mountain, which is still smoking, and occasionally, it is said, emits loud noises, has more than once devastated the region about its base. The vegetation upon its higher slopes is clothed, often densely, with fine ash. The Baños region is of wonderful scenic beauty with its 300-foot waterfall, towering mountains and the cleft-like Pastasa gorge. There are hot springs and a mineral spring in the village itself. Fairly comfortable quarters were secured in one of the few second-story houses of the village, while tolerable meals were doled out at the "Agencia Funeraria," the coffin shop being next the dining room. The district can scarcely be called tropical although it suddenly becomes so only a few miles to the eastward. Baños bananas are comparatively expensive and of poor quality, but the sugar cane plants, sometimes growing alongside of wheat or barley, have a better appearance than one would expect for so high an altitude. No particular variety

The Baños Rum Brigade climbing the Andes. The often unassuring bridges spanning these mountain gorges are braced and supported by steel rails.

of sugar cane is planted here; some of it was seen in tassel. The stems may be dark, striped or concolorous and one kind, grown on a very small scale, was nearly entirely purplish, leaves and all. The villagers go to some pains in raising cane, and nicely erect stalks stripped of the lower leaves were noted. The rum factory is operated in part by the abundant water power available in this rugged spot.

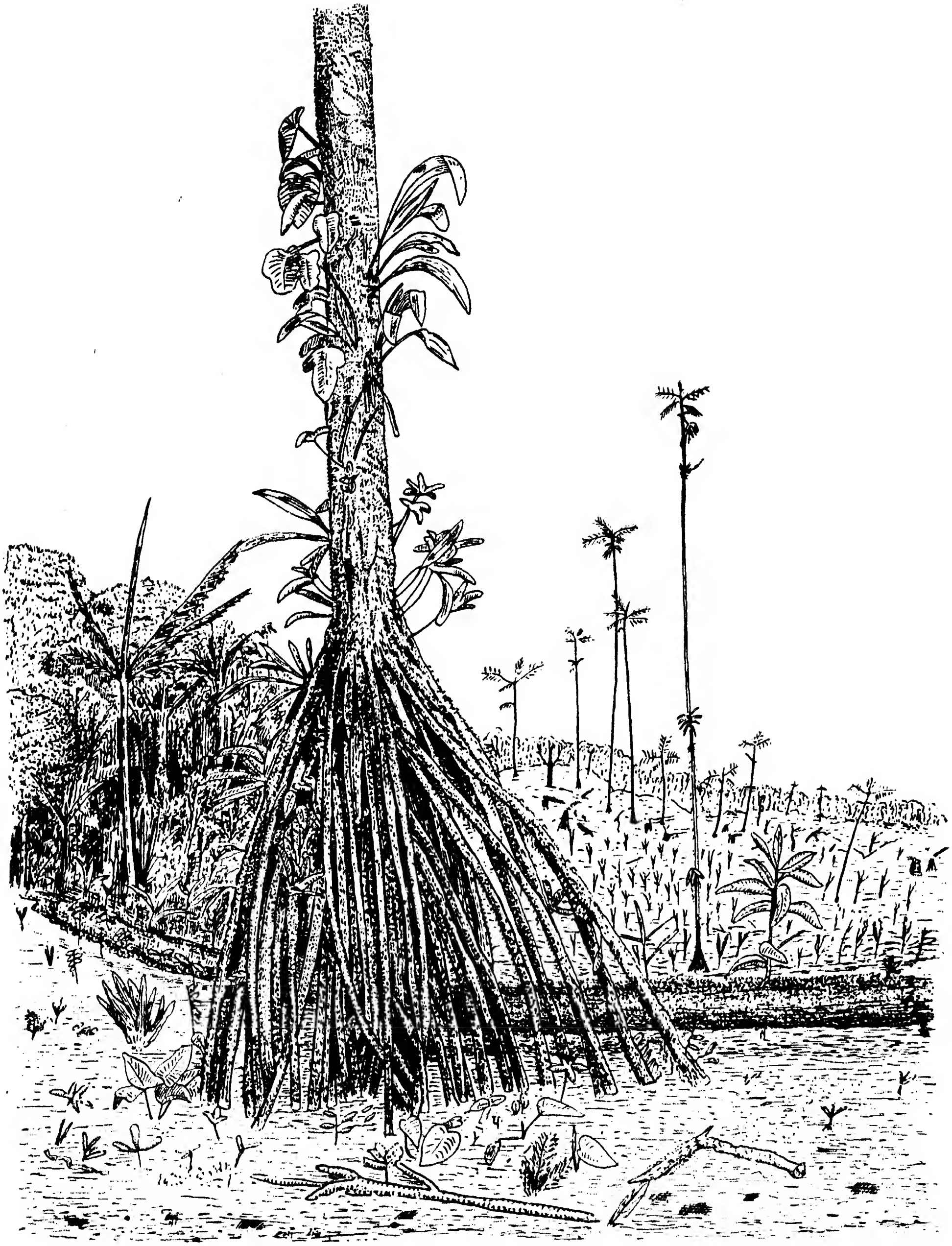
No sugar cane diseases were recognized. Of insect enemies the following came to notice: A *Diatraea* (?) moth borer; a leafminer, perhaps the same as occurs at Milagro; the larva of a skipper butterfly, devouring the leaves, as well as some leaf-feeding beetles (Chrysomelidae); the latter, though abundant, did not seem habitual on the plant; several species of leafhoppers, some being Delphacidae; and a froghopper or spittle insect (Cercopidae). The leafhoppers were not found breeding on the plants, as was the case to the contrary with the froghoppers on the shoots and stems, though this insect did not appear of major importance. Mole crickets were plentiful in certain cane fields. White grubs were abundant in grass lands, and their wasp enemy, *Tiphia* also present, as well as a huge *Scoliid* species.

Considerable digging, mainly in cane fields revealed several species of true wireworms as well as wireworm-like larvae. Here, as elsewhere in localities visited, wireworms of the *Monocrepidius* type generally prevailed over the slenderer forms. Among the species dug up were luminous examples of rather large size, presumably the larva of the "Cucuyo", *Pyrophorus* species. Another type though hardly a wireworm was the brilliantly lit up and very active larva of a *Phengodes* (?) beetle, an insect more related to the true "fireflies" (Lampyridae). An hour's digging for wireworms resulted as follows:

	Larvae	Pupae
Monocrepidius-like	**10**	**2**
" " but darker	5	0
Slenderer form	1	1
Phengodes	1	0
Wireworm-like larva	5	6
	22	9

Nothing was found attacking wireworms.

In hopes of meeting with better success farther within the luxuriant Oriente or eastern province of Ecuador, I left Baños for Tena near the Napo River, on January 22, 1923. As one descends into the Amazon basin the granite or granite-like rock of the mountains becomes more and more overlaid with soil, in many places turning into a morass, so that at Mera, some thirty miles away one finds himself at 4000 feet elevation, in an exceedingly verdant and watery region, so much so that the numerous slender palms have adapted *Pandanus*-like prop roots to better sustain themselves in the uncertain earth, and water bugs seem to consider the contents of the veriest hoof prints a permanent body of water. Here at the village of a very few, scattered, palm-thatched houses might be seen a domestic fowl knee- (or heel-) deep in a rain puddle scratching away and gobbling up any morsels that rise to the surface. It was noticed here that quantities of Guinea pigs are kept in the kitchens, to be served from time to time at meals. Mera is a mere notch in the wilderness, the Pastasa River at the base of the tall



This illustration shows the basal part of a feather palm in a clearing in the rain forest of eastern Ecuador. The plant has prop roots much recalling those of the Pandanus and which better sustain its slender height in the boggy soil. These palms are very useful; the central shoot furnishes an appetizing dish, the leaves thatching, while the stems when split open, cleaned out and unrolled, make good flooring and walls. Such palms, though only eight or nine inches in diameter just above the prop root system, not infrequently attain a height of a hundred feet or more.

bluff which skirts the settlement at the right, the soggy forest filling in the rest. The minute patches of sugar cane contained a species of stem froghopper and moth borers, while the felled and decaying palm trunks quickly attracted *Metamasius* weevils. The Mera cane is superior to that at Baños.

A more or less bog-strewn journey of several days, a short canoe ride down the Anso and the Napo rivers to the tiny village of Napo, with a very muddy stretch of five or six miles brings one to Tena, a pleasantly situated place of some forty inhabitants. While quite tropical, its altitude of nearly two thousand feet produces an agreeable climate. It is a healthy if depressing place. Bread and regular potatoes are almost unknown and molasses largely substitutes for sugar. The cane as usual, is cultivated chiefly for rum purposes; some of the plants were tall, stout-stemmed and of fine appearance. One erect variety springing from rather massive stools and with a bloom on the stem somewhat as in our H 109, attained a height just before tasseling, up to about 18 feet, with bare stem to 10 feet. These were more than a year old, however.

Sugar cane at Tena, in eastern Ecuador.

What appeared to be mosaic disease was prevalent on some weedy cane. Of noxious insects pertaining to this plant were the usual South American types. Two species of stem froghoppers (Cercopidae) were found, but one was not very exclusive on the plant. The leaves were eaten by the larva of a noctuid moth, and a borer, probably of the same family, affected the stems. *Metamasius*

weevils, insects allied to the cane beetle borer of Hawaii and farther east, were very numerous, the adults occurring on pineapples, araceous plants, *Inga* (Leguminosae) pods, banana and palm stems and sugar cane and breeding in the last three plants and badly damaging the cane. *Castnia licus,* a giant moth borer is occasional in cane and banana plants. The large juicy whitish caterpillar is eaten with gusto—as are many other, not altogether pleasing-looking insects, and the huge land snails—by the ever-hungry Indians of the region. Occurring sparsely as a cane leafminer is the larva of a Chrysomelid beetle. The presence of small ladybeetles (Coccinellidae) in cane fields would indicate some Aphid or mealybug pest there. No cane mealybugs were found, however, a small species feeding underground at the base of the stem of bananas is preyed upon by a little Coccinellid.

Tena was not a promising locality for wireworms. A quite large predaceous species was occasionally met with under the bark of a dead tree, and adults of smaller species were also collected.

Of pests of man and other animals, mosquitoes were usually not troublesome save in certain forest districts; buffalo-gnats (Simulidae) were common in the vicinity of some of the rivers and at times quite annoying; in fact, I noted that the backs of my Indian carriers were more or less closely stippled with the bites of these insects. The ordinary house-fly (*Musca domestica*) which swarms on the inter-andine plateau, and where it may sometimes be seen nearly concealing by its numbers the otherwise luscious-appearing strawberries sold by the Indian women at the railway stations, seemed exceedingly scarce about Tena. The vampire, a small, plain looking bat sometimes attacks man exhibiting, they say, a fondness for feeding at the big toe, or turning its attention to one's rostrum; the shoulders or the necks of horses and cattle not infrequently show dried drops of blood, the result of small wounds made by these creatures.

Plans having miscarried for the proposed trip down the Amazon, I retraced the hundred-mile journey to the city of Ambato on the highlands. Arriving in Guayaquil in the middle of May, 1923, to set sail therefrom on June 13, for British Guiana, via Panama, north coast ports of Colombia, Venezuela and Trinidad. Sailing first on the Chilean steamer "Palena", the journey was continued from Cristobal to Trinidad on the French liner "Pellerin de Latouche". We arrived at Port of Spain, Trinidad, June 30, but no steamer to British Guiana was available until July 10.

Trinidad is about half the size of the island of Hawaii and is the southernmost of the West Indies, being but a few miles distant from the Venezuelan coast. It is well forested and traversed by several mountain ranges. Among its chief products are sugar, cacao, copra and Angostura bitters, as well as asphalt from the far-famed "Pitch Lake", which covers an area of one hundred acres. Chiefly through the kindly offices of Mr. F. W. Urich, Government Entomologist, I was enabled to see something of the country and its agriculture and to become acquainted with some of the insects, both good and bad. Of canes, D 109 and B 156 are among the popular varieties. Uba cane, which resembles ours in Hawaii is planted locally, especially on the poorest lands where a hard-boiled variety does well enough and chokes out the weeds. It grows densely and a fire must be passed

through it before harvesting. Ninety-eight per cent white sugar is made in Trinidad, and in the one "factory" visited, both the maceration and the regular method of extracting the juice were used. One sugar estate at Caroni and another near San Fernando, as well as a couple of cacao plantations were visited. The sugar cane froghopper, *Tomaspis saccharina* was not bad at the time. Other pests are *Diatraea* and *Castnia licus* stem borers. A Chrysomelid beetle, *Myochrous armatus,* injures the cane leaves as does also the larva of one or more skipper butterflies (Hesperidae).

Wireworms as larvae and adults were not uncommon, but at least those related to our own *Monocrepidius* are here rather considered beneficial for their mainly carnivorous habits. They were dug out of old logs in cacao plantations and the beetles were also to be found among sugar cane. No insect enemies of wireworms were discovered, although a dead, lead colored Elaterid pupa taken out of an old log proved, on being opened, to be filled with a sort of round-worm (*Myrmis*?).

The mongoose seems generally not looked upon with favor in Trinidad, whose cane field and other faunae are such that they suffer much from the depredations of this animal. Birds and lizards are among the victims. Damage by rats does not appear to be very serious.

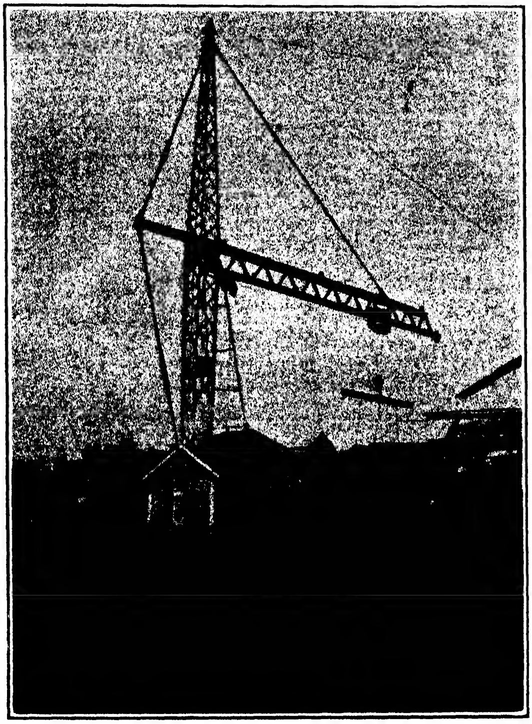
"Para" and "Kelley" grass are noxious plants. "Nutgrass" (*Cyperus rotundus*) occurs in Trinidad as also abundantly on the tropical mainland. It is attacked in the Neotropics by the boring caterpillar of a small moth.

There are some large cacao plantations; and many or most of them are shaded by "Immortels", a species of *Erythrina* tree. Windbreaks for these estates consist commonly of a plant appearing to be the same as or very close to our "Ti" plant, *Cordyline*. There is a coconut industry. The plantains are often badly attacked by the weevil *Cosmopolites sordidus.*

A journey of rather less than two days brings one to the low muddy coast of Demerara or British Guiana. Georgetown, the capital, is a city of about 60,000 and is situated at the mouth of the Demerara River. Demerara is also the name of one of the three counties of British Guiana, the other two are Essequilo and Berbice. The whole country lies between 0° and 9° north of the Equator. While the coast presents a rather uninviting appearance, the "hinterland" is magnificent, with its tall dense forests and rugged mountain range. Kaieteur Falls is a sheer drop of the Potaro River of 740 feet. Among the products of the country are cane sugar, Bauxite (Aluminum ore), gold, diamonds, "balata", which is the sap of a forest tree used for "belting and boot soles", and such fine timber as "greenheart" and "purpleheart." The soil of the front lands, as a rather narrow strip, is heavy "marine alluvium", with here and there a sand reef, and some peat-like material. So devoid of stones is this low area that baked earth is used in the construction of the coastal highways.

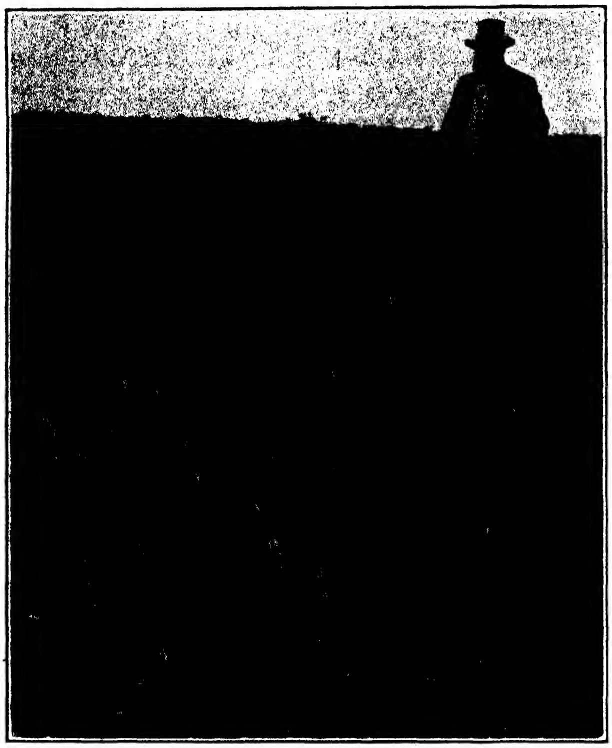
In Georgetown, the Department of Science and Agriculture and of the Lands and Mines, the Museum, and the Sugar Cane Experiment Station were several times visited. A short trip was made to the interior via the Demerara, Essequibo and Potaro rivers to Tumatumari on the Potaro River. Otherwise, the time was employed on and about sugar estates. These are all on or very near the coast,

which being below the level of high tide is protected by a great sea-wall provided with numerous sluice gates or "kokers" that at low tide release the pent-up fresh water. The sugar plantations are laid out in quadrangles, the boundaries being canals, of which there is also an extensive and well distributed system in these quadrangles, and serving as transportation or as drainage ways. Large animal-



Loading cane onto the carrier from punts. Berbice, British Guiana.

drawn punts of about 27 by 8 feet, with iron sides and "Mora" wood bottoms, and often in long trains, carry the cane from the harvested fields right up to the cane loader of the factory. Thus also to a large extent are the plows and caterpillars borne afield, for mechanical tillage has been going on here for some years. This sort of cultivation is feasible only in new lands, or in old fields where the ditches have been filled up to allow the passage of the 50 h.p. caterpillars and their plows. Ordinary forking by the task is the usual form of cultivation in the fields that do not permit plowing. The labor is chiefly East Indian. Bourbon cane was once extensively grown in British Guiana but eventually, as in some other countries, it ceased to be productive and is now replaced by other varieties, chief of which is D 625 produced through the efforts of Sir J. B. Harrison, Director of Science and Agriculture, and his associates. D 625 is a hardy yellow cane that resists drought well. It seems that here ratoon crops rather than those from plant cane yield the heaviest tonnage.



Newly planted cane in Berbice, British Guiana. The cane soon "peeps up" and each little shoot gives rise to five or six "pickaninnies." Note that the East Indian "driver" or overseer carries with him a brush for combatting mosquitoes.

The greater part of the time spent in British Guiana was at Plantation Blairmont, a few miles up the Berbice River and directly opposite New Amsterdam, the second city of the country. Here good laboratory facilities were available, and I am indebted to the officers of this estate, especially to Mr. H. E. Box, the Blairmont Plantation entomologist, as well as to Mr. W. H. B. Moore, the Albion Plantation entomologist, to Mr. L. D. Cleare, government entomologist, and to many others.

No mosaic disease was found either in Trinidad or in British Guiana. In the latter country a disease commonly referred to as *Marasmius* was not uncommon in certain cane fields, and was characterized, in gross fashion, by the affected plants turning brown as if burned, by a basal mycelium developing to mat the sheath trash against the cane stem, and by the stool pulling up very readily.

A little of the sugar cane entomology as well as other entomological data are set down in my notes of August 23, from a visit to one of the plantations. "In the afternoon we took a 50 minute mule-drawn bateau ride in one of the canals to where the 'borer gang' was working. This field was in very young plant cane, much of it drowned out by floods. The old 'banks,' i. e., the ridges

(at present) between rows and on which the old discarded ratoons were thrown to make room for the plant cane, had stools ratooning freely, so that this cane stand—not destroyed because of the shortage of labor—was taller and, in places, denser than that of the soggy seed cane, and furnished at the same time 'suckers' for 'supplying' (replanting) and a holdover place for borers. These borers were mainly the red-headed larva of the moth, *Diatraea canella*, and were being cut out by young coolies. The work is not arduous, for only growing shoots are operated upon, the 'dead hearts' locating the damage. In a badly infested field as in the one being considered, the worker need move but very little during the whole day, as sufficient material is close at hand. The infested shoot is cut sufficiently low, then shaved off until the borer is exposed when a few jarring taps with the knife partly dislodges it from the tunnel, to be seized and placed in a round tobacco box, whose base or lid the worker often hammers out into a bulge to enlarge its capacity. The catch eventually becomes a tightly packed mass of *Diatraea* larvae, with an occasional weevil borer (*Metamasius*) and more seldom still, a large larva of *Castnia licus*, the giant moth borer. The pay for *Diatraea* larvae and pupae on this plantation is four pence a hundred. Record catches mount up to 1000 borers per day, so that children may sometimes make more money in a day than do their parents engaged in other plantation work. The borer-gang may consist of more than 100 individuals. *Diatraea* parasites found during this work are reared in a laboratory and liberated. *Ipobracon*, other braconid wasps and a fly attack the larva. The moth lays her eggs in a patch on the cane leaves. A minute wasp, *Trichogramma*, may parasitize the entire egg-mass, when it assumes a blackish color. Another egg wasp, *Prophanurus alecto* seems less efficient. As we proceeded up the canal I swung my net along the little grass islands, and thus bagged numerous little flies and leafhoppers. Farther along, the nests of hornets (*Marabuntas*) of the genus *Polistes* were numerous on the canal's side boards, so that for a short space it was advisable to release the scraping towing line and resort to paddling. While hardly a cane pest, alligators are common in the trenches and are said sometimes to lay their eggs in the fields, and to furiously pursue anyone approaching the nest. I was told of and saw the 'yellowtail,' a large black snake, with a yellow tail that frequents the cane fields of British Guiana and is reckoned a very efficient rat catcher.

As we passed along the canal, for about a third to a half mile, lay heaps of burning termite nests, the dark, firm, ball-like structures certainly totalling far into the hundreds, if not thousands. These nests are collected from the cane fields where they are often attached to cane stalks, which the insects may damage considerably.

Mr. Moore showed me a very small bug living upon the surface of the trench water and most useful in destroying mosquito larvae, one jab of the beak being fatal to its prey. Mosquitoes are certainly surpassingly numerous at certain times of the year in many places along these 'front lands.'"

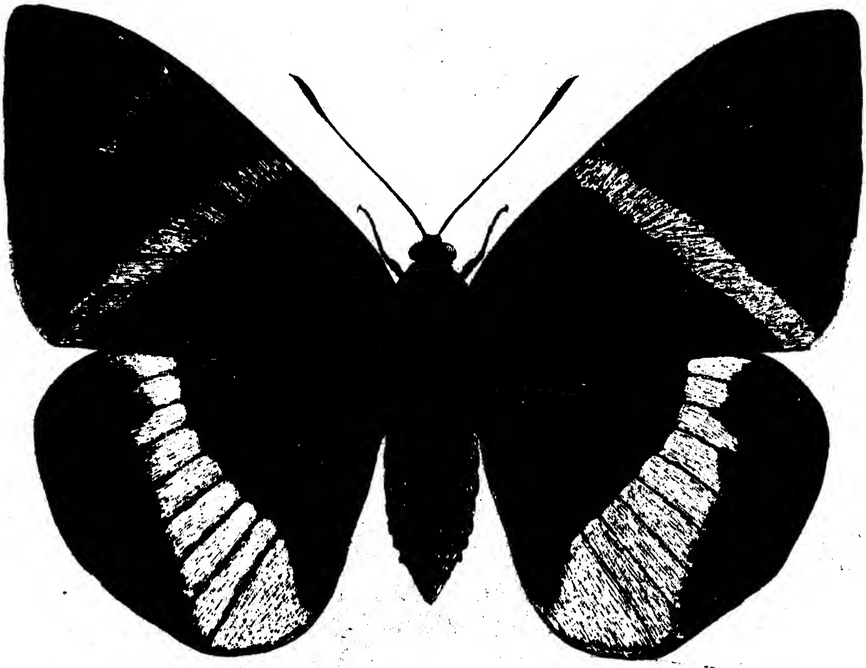
There are three species of *Diatraea* moth-borers, *D. canella, D. saccharalis* and *D. lineola* in British Guiana, the first two are the most serious cane pests, the last seems rather inconsequential. When full fed their slender larva is in

the neighborhood of an inch long. In addition to destroying the young shoots, the old joints are likewise attacked, and very frequently so many "eyes" or buds are eaten out of the seed pieces as to necessitate considerable replanting, or "supplying" as it is here termed. The borer also has the habit of working around within the comparatively soft root band so that the cane often breaks at that point from sheer weight, or because of the wind. The ubiquitous "razor" grass (Graminiae) as well as some other grasses are also *Diatraea* host-plants. The large conspicuous inflorescence of "razor" grass is very attractive to several species of wasp parasites of *Diatraea,* so that one may find numerous examples of an *Ipobracon* (?) upon them even to the exclusion of other insects.

It has been found by the government entomologist that immersing the "seed" cane in water for three days, destroys all the borers. At present, however, *Diatraea* is controlled neither by artificial nor natural agencies.

The giant moth borer, *Castnia licus* at one time was quite a serious pest and even now must be reckoned with. It has been found worth while to flood badly infested fields and thus destroy the borer, which usually restricts its activities to the lower part of the cane plant.

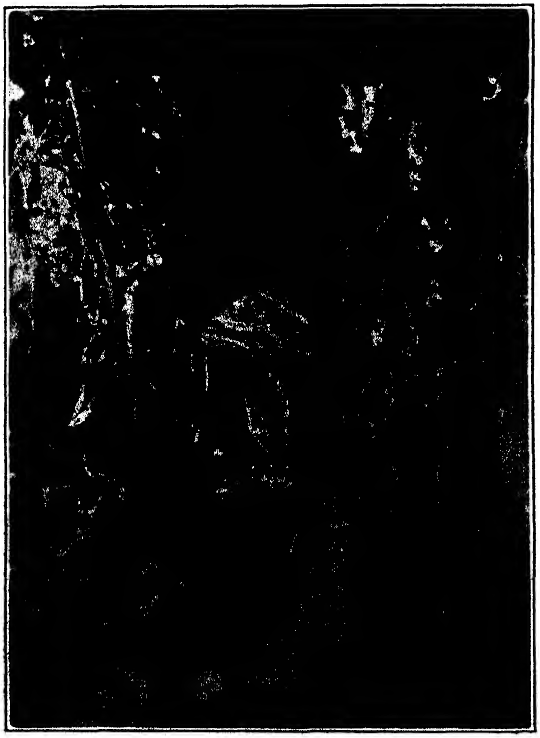
Castnia licus, full-grown larva from Tena, Ecuador. Slightly reduced.



Castnia licus, from Belen, Para. A moth native to tropical America, where its larva often bores the stems of sugar cane. X $\frac{4}{3}$

Following up mechanical injury, the damage caused by *Diatraea,* and infesting plant tops as well, is *Metamasius hemipterus,* a beetle borer related to *Rhabdocnemis obscura* of Hawaii and farther east, but differing from it among other things—in not primarily attacking healthy cane. The insect is abundant in some cane fields and seems to have no efficient enemy. There is a single record (Moore, 1915) of a wasp grub found feeding on a larva of this *Metamasius.* Later, by the aid of Mr. H. E. Box, I was enabled to examine over a thousand of the beetle grubs, with the result of finding a single very young wasp grub on a paralyzed larva; and in another case an adult *Ipobracon* (?) wasp (♂) just issued from a cocoon in a *Metamasius* burrow, the remains of the host being nearby. Examples of this species of wasp were subsequently taken on razor grass, but they could not be induced to do more than merely paralyze a few of the most advantageously exposed *Metamasius* larvae. From this experiment one might conclude that *Metamasius* is not the normal host of this wasp. Occasionally infesting cane stools is the larva of the palm weevil or "gru-gru worm," *Rhyncophorus palmarum.*

White grubs are sometimes troublesome, damaging the cane stools. The beetles are referred to as "hardbacks." *Ligyrus* sp. may be quite injurious. As everywhere in continental lands, these Scarabaeid larvae are attacked by certain flies and various Scoliid and Tiphiid wasps.

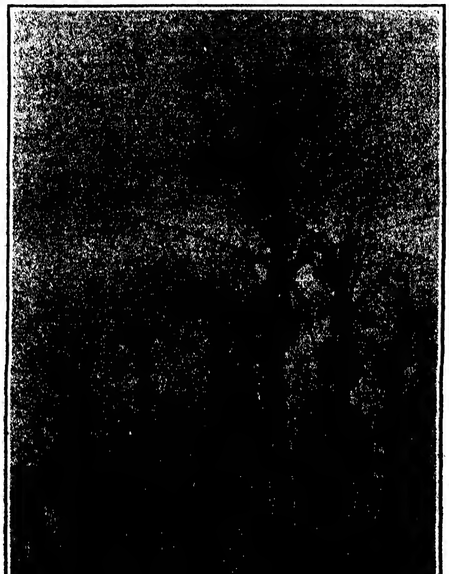


A large butterfly, *Caligo,* whose caterpillar eats the leaves of sugar cane, awaiting dusk on the trunk of a mango tree in British Guiana.

Of leaf-feeders, are several species of moth caterpillars of the family Noctuidae, and at least ten species of the larvae of the Hesperidae or Skipper butterflies. Such insects, however, do not for long increase beyond the control of their numerous enemies, which in the end slaughter them wholesale. Parasitic flies and wasps are among these foes. A solitary wasp of the family Eumenidae, noticed also in Brazil as the same or a related species, excavates shallow burrows in termite mounds or in the ground proper and stores them with some of these skipper butterfly caterpillars. A fine large butterfly, *Caligo* sp. with a larva that is occasionally common on cane plants has never become numerous enough to be considered a pest.

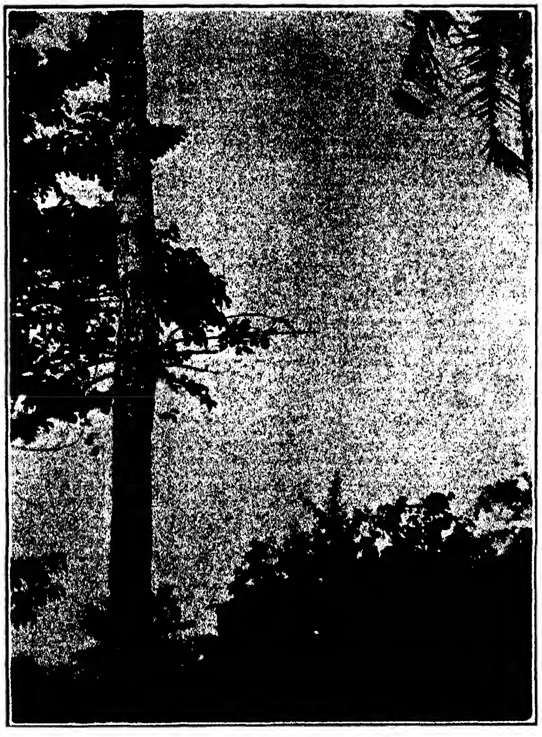
The cane froghopper has not taken hold in British Guiana. Of aphids a very few, in diminutive clusters, were found on the plant. They appeared a different species from the one in the Pacific and were attended by a ponerine ant. Mealybugs, of which several species occur on cane, are sometimes very abundant. A *Metarrhizium* (?) fungus destroys a great number, while among their insect enemies, are the caterpillar of a tineid moth, a cecidomyid fly maggot and several species of ladybeetles.

Wireworms allied to our injurious forms were not found plentiful.



Coconut palms in British Guiana attacked by the larva of *Brassolis*, an evening butterfly. By day the caterpillars lie concealed in the sack-like retreat and issue at nightfall to feed.

Two insects conspicuously injurious to the coconut palm (*Cocos nucifera*) in this part of the country are the larvae of a rather large butterfly, *Brassolis sophorae,* and that of an immense moth *Castnia daedalus.* The larvae of *Brassolis* construct a silken nest among the leaves, sallying therefrom at nightfall in large numbers. The damage they do to the palm leaves is much greater, though perhaps more periodical than the depredations of the coconut leafroller of Hawaii. They pupate singly on the underside of palm leaves, walls, or any other convenient pláce. *Brassolis* butterflies are native to South America and their unsightly work is also apparent on the Royal Palms, *Oreodoxa* of Rio de Janeiro, in Para, and elsewhere. The larva of *Castnia daedalus,* makes rather superficial tunnels along the stem, chiefly the upper growing part of the coconut palm, so that in later years the affected plant shows a series of deep furrows, some of which may penetrate well into the interior.



Among the numerous species of palms one sees in South America none seems to suffer more from the depredations of insects than the coconut palm (*Cocos nucifera*), a plant native to the Eastern Hemisphere. The photograph shows the stem of one of these palms disfigured by the borings of a giant moth caterpillar, *Castnia* sp.

The number of beneficial insects as well as the abundance of insecticidal fungi in the front lands of British Guiana is striking. There are many species of ladybeetles (Coccinellidae), insects that in great measure feed upon aphids,

scale insects, mealybugs, white flies (Aleyrodidae) and even upon leafhopper (Delphacidae). One species devours a fungus. While corn is sometimes rather heavily infested with Aphids, the enemies of these insects are quick to transfer their attention from the often comparatively meager fare on grasses and weeds to attack and quickly clean up a corn aphid infestation. I believe that the lady-beetles are the most efficient of these aphid enemies, and at least four species may be found on this plant. Of these the widespread *Cycloneda sanguinea*, a large reddish species is perhaps the most conspicuous and generally abundant; *Ceratomegilla maculata*, another large species is always rarer. A third species of these Coccinellidae, probably a *Hyperaspis* does very good work. The fourth species, quite small, is less plentiful and was found to pupate gregariously on the leaves. Two kinds of Syrphid flies were observed on corn and other aphid-infested plants. The larger of these flies, bluish black with the basal half of the wings fuscous and with a partly brick red larva was always to be had in an aphid colony, the second fly was smaller and was very common in weedy fields. I believe that *Cycloneda sanguinea* and the larger of the two Syrphids were the main eradicators of the corn aphid. A lace-winged fly (Chysopidae) was likewise a conspicuous enemy of the corn louse and of other small insects. Thus corn is rid of aphids, but a tall reed-like grass, related, I believe, to *Arundo*, often shelters quantities of a large pale green plant-louse for longer periods, which no doubt in many cases serves as an alternate host and so helps to tide over these beneficial predators.

Lepidopterous larvae are attacked by many kinds of wasp and fly parasites. Cockroaches have numerous wasp foes. A large solitary wasp of the genus *Monedula* stores its burrows mainly with horse-flies (*Tabanidae*) that pester the stock. Social wasps, whose mecca is the American tropics, destroy innumerable caterpillars. The nests of these wasps range in size from less than a ping-pong ball to an expanse of a large umbrella. As in human beings, these insects vary much in temperament according to species. The smaller ones seem usually mild or timorous—a fortunate state of affairs, as in passing through the bush their nests are very frequently disturbed. A species of *Cerceris* wasp nesting in small secretive colonies stores its four-foot deep burrows with weevils, *Eustylus* and one or more other species, somewhat allied to Fuller's rose beetle, *Pantomerus godmani*, which is frequently troublesome in Hawaii. The sugar cane mealy-bugs and relatives are at times nearly eradicated in places by a green fungus, probably *Metarrhizium*, while *Cordyceps* (?) fungus sprouts fantastically from other insects.

Here and there amid the fields of cane, perches of bamboo branches have been set into the ground for the purpose of encouraging the many insectivorous birds of the region to frequent this environment and there attack the noxious insects. Among such birds are the Kiskadee (*Pitangus sulphuratus*), a large, very useful flycatcher of bold and noisy habits; the "Old Witch" or tick bird (*Crotophagus ani*), that often accompany livestock apparently for the purpose of feeding on the insects aroused by the movements of these animals; the Guiana blackbird (*Quisqualus lugubris*), and the black and white "washer-woman"

(*Fluvicola picta*).

On December 13, I set sail for Rio de Janeiro, Brazil, with Barbados as a transshipping point. Early in the morning of December 17, we dropped anchor at Bridgetown, Barbados. The island is rather low, of tame profile and almost depleted of natural forest. It has the earmarks of an oceanic island, appearing largely of coral formation, with an insect fauna very impoverished in comparison with that of Trinidad to the south. It is an agricultural country and also enjoys a considerable winter tourist trade. The population, mainly negroes, is dense and the whole island has a spick and span appearance.

I am much indebted to Mr. John R. Bovell, superintendent of Agriculture, and to his assistant for information and opportunity of seeing some of the sugar cane cultivation of the island. Sugar cane is cultivated very efficiently. The seed pieces usually of three eyes each are planted in drills. No fire is run through the fields to facilitate cropping. Apart from the modern sugar factories of the island, are small mills where the cane is crushed through the operation of immense windmills, which in some places are a feature of the landscape. Barbados yielded a very effective parasitic wasp when its *Tiphia parallela* was shipped to Mauritius where it is said to control the white grub, *Phytalus smithi,* of that country in a manner comparable to the work of *Scolia manilae* on *Anomala* grubs in Hawaii.

On December 21, I took the Lamport and Holt steamer *Voltaire,* for the south and ten days later arrived at Rio de Janeiro, the beautiful capital of Brazil, a city of more than a million inhabitants. It lies just within the Tropic of Capricorn, and geologically speaking is in a very ancient region. The rocks are largely gneiss, a granite-like material much used in house building and other construction work there. The layer of soil on these rocks is often very scant and the virgin forests, which extend right up to the city, are composed of medium sized trees. Among the landmarks of Rio are the "Sugarloaf" (Pâo de Assucar, 1312 feet) and the "Hunchback" (Corcovado, 2614 feet) rugged precipitous peaks of solid rock, accessible in the first case by an aerial cable car, and in the second by a cogwheel railroad.

Brazil, which has approximately the same area as the United States, is composed of twenty states and the territory of Acre. The states are governed by presidents. The money is decimal, and as in Ecuador and some other countries, subject to annoying fluctuations. Coffee, first in value of Brazilian products, is grown chiefly in the Sâo Paulo region. Other important products are cacao, cotton, tobacco, cattle, sugar and Brazil nuts. Rubber has taken a back seat, at least for the time being.

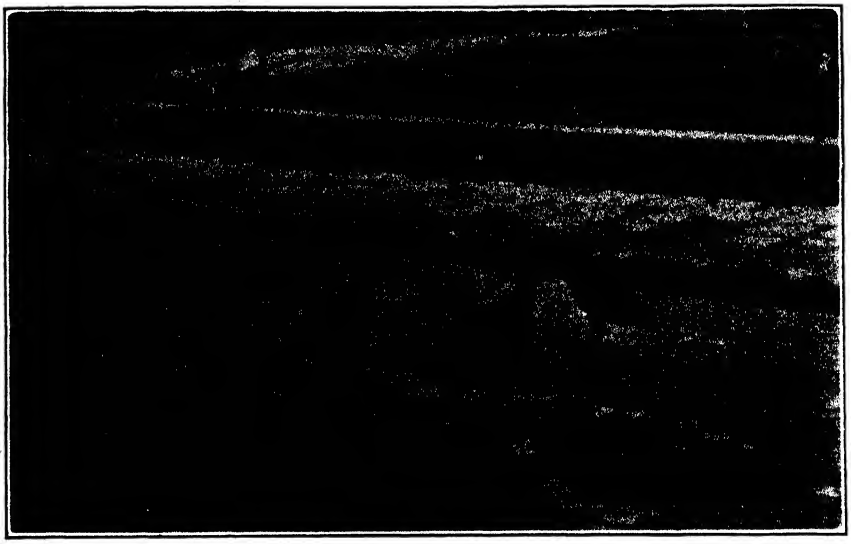
I am particularly indebted to Dr. Angelo M. da Costa Lima, entomologist in the Department of Agriculture at Rio de Janeiro for his many kindnesses, especially in regard to entomological information and letters of introduction.

The sugar cane industry of Brazil is not in a high state of development. The chief sugar district lies in around latitude 8° south, in the state of Pernambuco; other districts are Campos, in the state of Rio de Janeiro, and Campinas and Piracicaba, near Sâo Paulo. The sugar cane about Pernambuco is obviously superior to grown in the south, where the climate is not so well suited to this

tropical plant. The soil about São Paulo is said to be decomposed basalt; it is of a reddish color and looks like some of our Hawaiian soils; that about Escada, Pernambuco, appears much like fine, partly sandy alluvium, while in Para, near the Equator, it is very sandy except for a rather thin layer of dark top soil. The cane varieties go mainly by their Portuguese names; as Canna Preta, Canna Roxa, Canna Riscada, Canna Branca and Canna Manteiga. In the south, Canna Preta and Roxa suffer considerably from mosaic disease. Cavangire and Cayenna canes were seen in Para. At Campos, I spent several days at the Experiment Station, and at Piracicaba, visited the Agricultural School and the Fazendas (Estates), Costa Pinto, Monte Alegre and Taquaral. At Campinas, considerable time was spent at the Experiment Station plantation and two visits made a little beyond to Villa Americana. In the state of Para, in northern Brazil, a short trip was made from Belem up river about eight miles, to a small area of periodically submerged cane grown for the manufacture of Casaça or rum. Thereabouts also were scattered patches of cacao. Another sugar cane district 100 kilometers by rail from Belem was reached after a most distressing ride of 10 hours, the wheezing locomotive pausing now and then to pick up firewood or to gather breath before negotiating a grade or curve.

Diatraea moth-borers are common also in Brazilian cane fields. At Campos, I was shown two larval parasites of this pest, one a Tachinid fly, the other a Braconid wasp. The *Metamasius* weevil as a cane pest seems generally scarce in this country, at least in the more southern sections. It was said to sometimes attack cane about Pernambuco, and may be present in palms, etc., in the Amazon region. *Cosmopolites sordidus,* its relative in banana stems, was taken in Campinas. Armyworms at times do considerable damage to the leaves, as may the white grub of *Ligyrus* to the roots. Squads of immature grasshoppers of the genus *Tropidacris,* composed of huge insects, are sometimes found in cane fields. Froghoppers or spittle insects of several species are among the sugar cane insects here, and at least one species that feeds largely upon the superficial root system of this plant is reported as quite injurious. I believe, however, that cleaner culture would reduce these insects to a great extent, as they are likely to abound in weedy fields. Mosaic disease was found to the south, a district in which corn was also extensively planted, being frequently alongside of, or even intermixed with the cane.

I worked up from southern to northern Brazil, completing my stay in that country in Belem, the capital of the state of Para, in which I remained nearly two months. Belem is some distance from the Atlantic Ocean and is situated on a branch of the Para River, sometimes considered one of the mouths of the Amazon. The true Amazon is to the north, where it is intersected at its mouth by the Equator. A striking feature, at least to the stranger in Belem, is the abundance and the tameness of the black-headed vultures, here known as "Urubus." These funereally clad birds are early to anticipate the garbage wagon in its morning rounds, when they may be seen scampering in all haste with outspread wings after this sumptuously laden vehicle and perched ~~on it~~ helping themselves to the contents. More agreeable scenes are to be found in a later walk along the mango-shaded streets, or a visit to the small though interesting zoological



A triumvirate of city scavengers. "Urubus" in Para, Brazil.

gardens. In this region, as in many others in South America, one cannot fail to notice the "Sauba" ant and its depredations. This insect, also known as the "leaf-cutting" or "parasol ant" belongs to the genus *Atta*, stores its very extensive underground nests with bits of leaves freshly cut from trees or lesser vegetation, including even the sugar cane. Thus plants may be quite stripped of their leaves, which are used by the ants as a medium upon which to cultivate the fungus upon which they feed. Long lines of these insects, each ant bearing its leaf bit aloft, are a common sight crossing roads or following their own path-like trails. The "Saüba" ant then is a serious pest in the American tropics, and while efforts have been made to combat it, the fact that a colony of these insects my constitute, so to speak, an underground village, makes the task a difficult one. The ant is not without its use, however, for the very large, fat-bodied queens, when with the males they issue forth on their nuptial flights in immense numbers, furnish a welcome addition to the scant bill-of-fare of many an Indian family.

A hunt for wireworms at Rezende, at Campinas and at Piracicaba yielded numbers of one or two species allied to the *Monocrepidius* type. In one case, adults of one species could be secured in large numbers on the leaves of corn. In this section of Brazil the larvae have been found damaging the roots of corn, cotton and other crops. No wireworm enemies were seen.

In the city of Belem I found several beneficial insects which might prove useful in the Hawaiian Islands. For the purpose of securing enough of these and of breeding them some sort of laboratory was necessary. Fortunately, a very good place was found as a room in a large house, itself in a big garden, the whole of which was rented by two men engaged in the business of collecting and selling living zoological specimens of almost every description. A large section of the yard, for example, was devoted to artificial fish ponds stocked chiefly with small

mosquito-eating fish, said fish being sold to the Rockefeller Commission which used them in their mosquito campaign. The remainder of the yard was taken up largely with monkeys, deer, birds, etc., supplemented with cages of various kinds of parrots, macaws and parrakeets, so that one might almost take a course of natural history there.

The very city of Belem abounds with mole crickets, of which two species were noticed. They infest the sandy soil of the parks and even work between the cobblestones of the streets. Each species of mole cricket has its wasp enemy, active insects that belong to the genus *Larra*. Sufficient mole crickets were dug up in the yard to use for purposes of parasitization. This digging, mainly in clean sandy soil revealed in addition, the larvae and adults of a predaceous ground beetle with largely subterranean habits. It is a medium-sized black beetle of the genus *Scarites* of the family Carabidae, and may prove a possible enemy of wireworms, white grubs, and the larva of Fuller's rose beetle (*Pantomerus godmani*). A wasp that preys upon middle-sized cockroaches and belonging to the genus *Podium* was secured in some numbers in immature stages. All four species of these insects were successfully transported to Hawaii and liberated in small numbers in what appeared to be favorable situations.

The return trip from Belem, Para, to Honolulu, Hawaii, a journey of over 8000 miles, via New York and San Francisco, was accomplished in 27 days, including a delay of four days in San Francisco, leaving Belem July 1, 1924, and arriving in Honolulu July 28, 1924.

Tolerably large collections of insects were made in South America, including a representative assemblage of sugar cane pests, and many other insects of general interest and of economic importance.

The explorations failed to bring to light any insect parasites of Elaterid wireworms, though wireworms themselves were at times quite abundant. No doubt, further search would in the course of time yield more or less effective parasites of these insects.

Pineapple Insects.

The pineapples cultivated in the environs of Guayaquil, Ecuador, are frequently of large size, their meat is delicate, white and well flavored and containing tolerably large seeds. At San Miguel, about 20 miles from Guayaquil, was a small plantation of pineapples. The plants had a healthy appearance and the fruits often bent the stalks by their weight. The pineapple mealybug was common enough but found in quantity only on young fruit still in blossom. Three such affected fruits were kept in a glass jar for over two weeks in hopes of rearing internal parasites of the mealybug. None such was obtained, however, although some midge-like flies were produced from orange-colored maggots that were feeding underneath but probably upon the mealybugs. The maggots spun whitish cocoons and the pupae were partly extruded from them when the adults emerged. A small, dark-colored Ladybeetle (Coccinellidae) with a mealy larva was another enemy of these coccids. A little moth larva was common on the fruits where it fed apparently upon available debris. The larva of a Lycaenid butterfly of the *Thecla* group was twice found feeding on the pineapple. Its fat, little slug-shaped larva bores into the fruit inducing decay. It is a prolonged

and heavy eater and undoubtedly quite a pest. Two butterflies were reared to maturity. The insect has a wide distribution in tropical America and I recall a caterpillar of this or a related species as being intercepted in quarantine in San Francisco in 1909, on a pineapple hailing from Mexico or Central America.

The pineapple belongs to the Bromeliaceae, a family so immensely developed in the Neotropics that it is no doubt the home of our edible species. "Wild pines," as they are known in British Guiana, are represented as large plants but with small though delicious fruit. The Bromeliaceae occur both as terrestrial and tree-dwelling forms; of the former are several fibre-producing plants, while of the latter we have the so-called "Spanish moss" (*Tillandsia*) and a host of other kinds, some with very handsome inflorescences though a comparative superabundance of leaves. Not a few have rather pleasantly flavored if diminutive fruits.

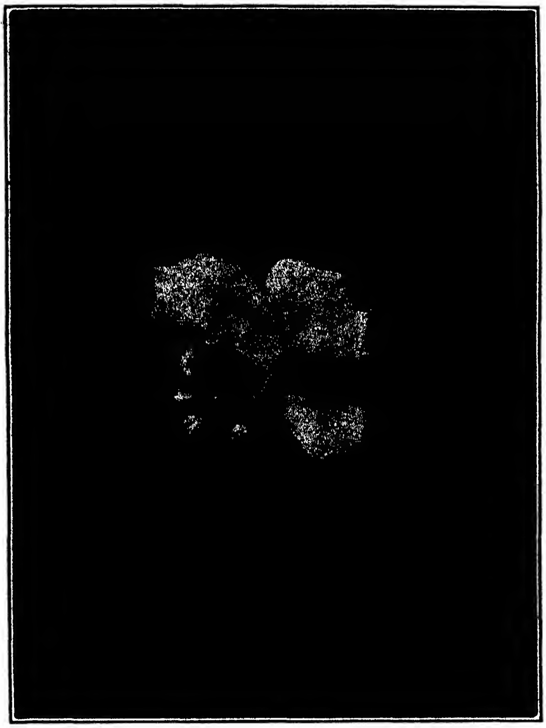
Forest Conditions

In parts of South America many desirable forest trees, palms and flowering plants were observed. On entering a forest, however, a feeling of helplessness seizes one as he views the assemblage of unknown forms, only here and there doubtfully recognizing some specimen.

In the immediate vicinity of Guayaquil, Ecuador, there are bignoniaceous trees that blossom out before leafing, and such appear from afar as a mass of deep yellow, that rival in beauty the "Golden Shower" (*Cassia fistula*) of Hawaii. In the same environment are certain rather large trees that produce capsules containing downy material with commercial possibilities, while the large, loose, wild cotton bush (*Gossypium*) is spangled with masses of white. More to the interior in the damp forests, palms show great development, from the yard-high dwarf in fruit to slender giants that may exceed 100 feet in height. What was described to me as a "Palma Real" is a tall species that grows at proper elevation on the eastern slopes of the Ecuadorean Andes, where, surpassing in height the trees of the forest, it forms the skyline along the mountains. Strangling fig trees, known in Ecuador as "Matapalos", while by no means so numerous as in the Philippines, often attain an immense size, standing out in otherwise cleared areas of virgin forests as solitary giants too huge and useless to be cut down. On the Andean plateau, the *Eucalyptus* has been planted and has proved valuable both for construction purposes and as firewood, quantities being used for the locomotives of the Guayaquil and Quito Railroad. The so-called pepper tree (*Schinus mollis*) grows naturally in parts of this high land, as does the "Capuli", (*Prunus salicifolius*) a pretty tree with execrable fruit. A departure from ordinary willows is to be found in the "Sauce" (*Salix humboldtiana*), a tall slender tree with much the same habitus as the Lombardy poplar. The "Sauce" is conspicuous in the Andean village of Baños, where examples attain a height of fifty feet or more. Epiphytes (plants which grow on other plants, but do not derive their nourishment from them) often "sit" on trees in immense numbers, particularly in the moister regions; this is especially true of various Bromeliaceae (pineapple family), Araceae (relatives of the "Calla lily"), and of orchids. Scandent cacti are well represented, though perhaps not in the dampest forests. Many of these cactus plants root upon the host itself, not sending other roots

A bromeliaceous plant in eastern Ecuador. This particular species is apparently not found high up in the crown of trees, but fastens itself lower down to the trunk or to stumps. It has petiolate leaves and thus harbors no water in which mosquitoes may breed. In the flower-season it sends forth a beautiful carneous red spike which later discloses yellow flowers. The spike illustrated is about twenty inches long.

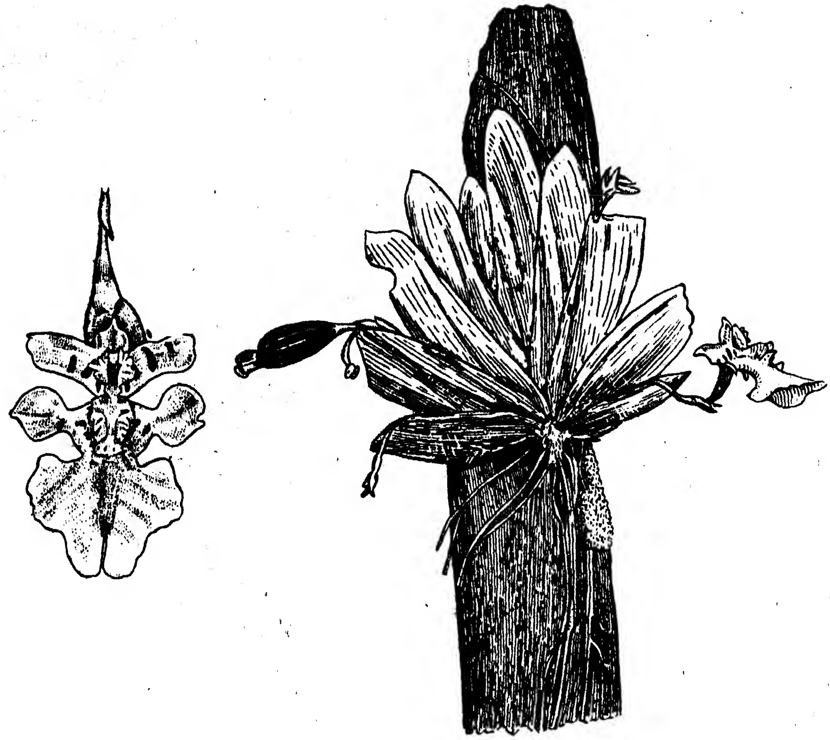
to the ground. Numbers of the Bromeliaceae bear a handsome inflorescence, pinkish, red, yellow, etc.; their leaf bases may hold considerable water, which forms a good breeding place for mosquitoes, Psychodid flies and other aquatic insects as well as for certain tree toads. The Araceae may be represented by dozens of species even within a very circumscribed area; many are terrestrial and a few that flourish in bogs or meadows are among the most attractive. Handsome orchids are to be found as high up in the Andes as 10,000 feet; terrestrial species are common though often inconspicuous; over a dozen kinds were observed in the neighborhood of Baños. The *Sobralia* are very handsome terrestrial



Sobralia sp. A terrestrial orchid common about Baños, Ecuador. A much handsomer and larger *Sobralia* is found at lower levels.

orchids, with white or purple and white flowers three to five inches in diameter. These are terminal from graceful leafy stems, and the plants were found often in numbers along river banks, or on steep slopes at about 5,000-6,000 feet elevation. A fine white-flowered lily (*Eucharis* sp.) grows naturally in the forests and is much used as an ornamental plant in some tropical cities.

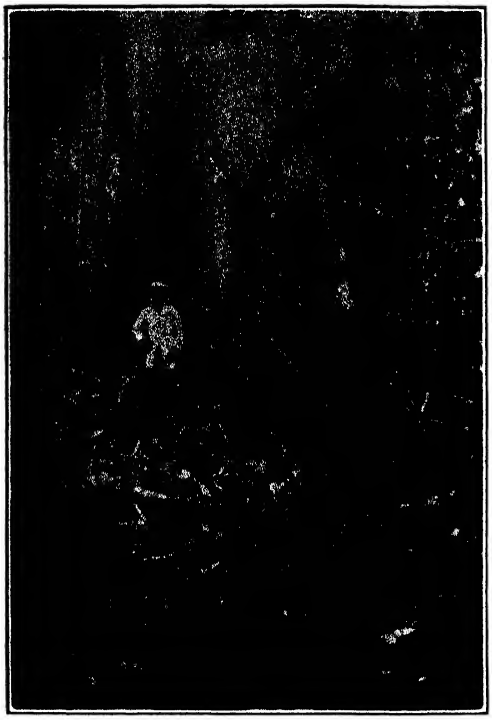
In British Guiana are immense forests composed of many species of trees, with giants such as the great buttressed "Mora" (*Dimorphandra* sp.) a conspicuous element. Along the lower reaches of the rivers and near the coast, the wide-crowned silk cotton tree (*Ceiba pentandra*) rises above its fellows.



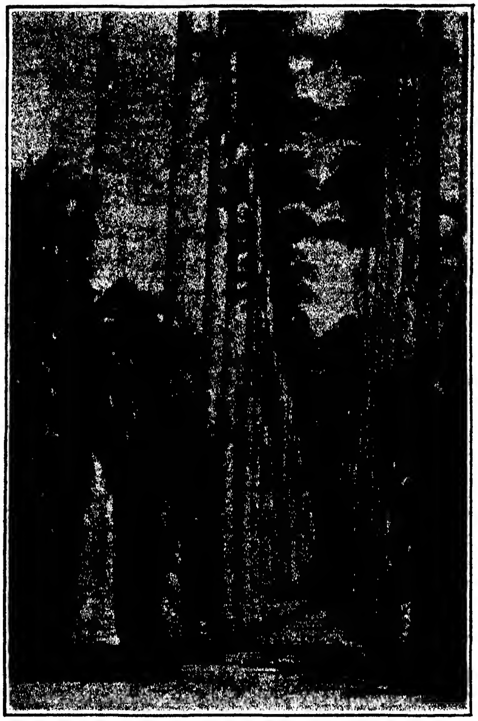
A small species of orchid. The plant is fan-shaped, clinging by means of its roots to a branch or leaf; the comparatively large flowers are few and yellow with brown spots. It is common in eastern Ecuador, where it grows and flowers occasionally in such profusion on a tree as to give the latter the appearance of being in blossom. Plant ¾ natural size. Separated flower about $X \frac{4}{3}$

The Sand-box (*Hura crepitans*), a sort of weed tree of poisonous character is another huge, quickly growing species whose trunk is studded with close set spines.

The forests about Rio de Janeiro, while really tropical, are, generally speaking, formed of medium large trees. There are not a few trees here that in the flowering season stand out as gorgeous masses of yellow in a background of dark green, while a small tree belonging to the Melastomaceae is equally beautiful in its garb of magenta blossoms. Conspicuous in second growth areas is the rapidly growing *Cecropia* tree represented by several species; other species of this genus by reason of their pale leaves, stand out in the forest as conspicuously as, though singly or in smaller groups, than the "Kukui" (*Aleurites moluccana*) of the Hawaiian Islands. Growing in moderate abundance upon unhealthy trees between Rio de Janeiro and Campos, was a species of *Cattleya* (?) orchid with handsome purplish flowers; this was one of the few instances noted where orchids were conspicuous for their abundance as well as for their beauty.



A giant *Hura crepitans* tree in the lowlands of British Guiana. It is a quick-growing weed tree of little commercial value.



Royal palms (*Oreodoxa oleracea*) in the botanic gardens at Rio de Janeiro. The palms attain a height of well over 100 feet.

Most of the tropical cities were well planted with shade and ornamental palms and trees. Of the first, the Royal Palm (*Oreodoxa oleracea*) was by far the most striking in Brazil. While not having the whitish stem of the *Oreodoxa regia* in these Islands, they exceed the latter in grace and stature, and aisles of these fine palms show many an individual a hundred or more feet tall. As in the Orient, wild fig trees are favorites in South American cities. The commonest fig tree in Brazil, and it seems to be the same as grown in Guayaquil, was of the strangling type and given me as *Ficus livida,* obviously a close relative of *Ficus retusa.* Other common city trees were *Terminalia catappa, Grevillea robusta, Moquilea tomentosa,* a species of *Artocarpus,* and the "Rain Tree", *Samanea saman.*

Sampling Sugar Cane for Juice Analysis

By J. A. Verret

The commercial value of a sugar cane variety is almost entirely dependent upon its yield of cane per acre and the amount of sugar which the cane contains. When one has fairly large amounts of a variety it is not a hard problem to determine its sugar content. But when one is working with but small amounts of new seedlings or bud selection progenies the problem is much more difficult. Analyzing a few whole stalks at harvest time is not satisfactory in that the results vary within such wide limits from year to year as to be of no great value except as rough approximations.

In the *Memoirs of the Department of Agriculture in India*, Botanical Series, Vol. VIII, in an article entitled "Studies in Indian Sugar Canes," C. A. Barber mentions very briefly a method of sampling which appealed to us as being very sound.

The method is based on the assumption that that part of the sugar cane stalk from which the leaves have matured and died is to all intents and purposes, ripe.

We tried this out this season with what seems to us to be very satisfactory results.

In our bud selection work it is very important to know as soon as possible the sugar content of the various progenies selected. It seems to us as reasonable to assume that bud sports occur affecting the sugar content of a variety as well as the tonnage of cane. The problem was one of sampling.

We have growing at the Makiki Plots, 37 lines of selected H 109, consisting of five different progenies. These were selected several years ago and have been harvested three times.

We decided to make a juice determination on these progenies, using the so-called "dry leaf portion" method mentioned above.

The cane was plant. Seed pieces with all eyes, but one, being gouged out, were used in planting. The eyes were spaced two feet in the line. The lines were 30 feet long, giving 15 stools per line.

In sampling, primary stalks only were used. This can be easily done in plant cane with single eye planting. This gave a maximum of one stalk per stool and 15 per line. Primary stalks were taken in order that all stalks be of the same age.

All stalks were very carefully examined and all which were in any way damaged were discarded. This examination was made both in the field and at the mill. The single stalks were run through the small mill one at a time and the juice from each taken separately. As the crushed stalk emerged from the mill it was carefully examined and whenever appreciable discolorations were noted the juice was discarded. We found this to be the best way to make sure that juice from sound stalks only was being taken.

The stalks were topped immediately below the highest node which held a dead leaf, that is, a leaf which had matured and stopped functioning. With this particular cane this point was generally fifteen leaves from the top, counting the

last rolled leaves as one. The rate of joint formation on the primary stalks seemed to have been very uniform, as the large majority had from 24 to 26 matured joints when sampled.

In the following table we give the results obtained. The analyses represent the average for each line, consisting generally of 15 stalks. A few stalks were discarded on account of borer or other injury.

Row No.	Prog. No.	Brix	Pol.	Pur.	Q.R.	Tons cane per acre	Tons sugar per acre
1 (outside line)	5	16.6	15.18	91.4	8.60	61 9	....
2	3	16.7	15.44	92.5	8.38	68.2	....
3	1	16.6	15.21	91.6	8.56	64.0	....
4	3	16.0	14.71	91.9	8.84	67.2	....
5	1	16.4	15.05	91.8	8.64	74.0	....
6	3	16.3	14.93	91.6	8.73	71.7	....
7	1	16.4	15.08	92.0	8.61	70.3	....
8	2	16.5	15.16	91.7	8.57	57.5	....
9	1	16.2	15.08	93.1	8.55	62.8	....
10	3	16.4	15.24	92.9	8.47	65.0	....
11	1	16.6	15.41	92.8	8.38	53.7	....
12	2	16.8	15.70	93.5	8.19	57.8	....
13	1	16.7	15.51	92.9	8.31	59.2	....
14	3	15.9	14.55	91.5	8.96	59.8	....
15	1	16.5	15.24	92.4	8.50	69.7	....
16	2	15.9	14.42	90.7	9.10	64.9	....
17	1	16.4	15.05	91.8	8.64	68.2	....
18	3	16.0	14.57	91.1	8.97	61.4	....
19	1	16.0	14.73	92.1	8.81	72.6	....
20	2	15.9	14.57	91.6	8.91	62.6	....
21	1	16.1	14.71	91.4	8.87	65.5	....
22	3	16.3	14.95	91.7	8.71	78.0	....
23	1	16.3	15.10	92.6	8.57	58.4	....

Row No.	Prog. No.	Brix	Pol.	Pur.	Q.R.	Tons cane per acre	Tons sugar per acre
24	2	16.5	15.39	93.3	8.37	58.5	....
25	1	16.4	15.27	93.1	8.43	51.6	....
26	3	16.5	15.39	93.3	8.37	66.9	....
27	1	16.5	15.34	93.0	8.41	66.0	....
28	2	16.8	15.56	92.6	8.31	69.8	....
29	1	16.7	15.44	92.5	8.38	65.9	....
30	3	17.1	15.83	92.6	8.17	62.8	....
31	1	17.0	15.88	93.4	7.92	60.1	....
32	2	16.8	15.68	93.3	8.22	58.5	....
33	1	16.8	15.68	93.3	8.22	60.1	....
34	3	16.2	14.85	91.6	8.77	57.4	....
35	1	17.0	16.00	94.1	7.82	62.4	....
36	2	16.5	15.14	91.7	8.60	64.5	....
37	1	16.8	15.54	92.4	8.33	63.3	....
38 (outside line)	4	16.9	15.64	92.5	8.28	79.4	....
Ground							
Aug.	1	16.5	15.30	92.6	8.46	63.8	7.53
"	2	16.5	15.20	92.3	8.52	61.8	7.25
"	3	16.3	15.05	92.1	8.62	65.9	7.64
"	4*	16.9	15.64	92.5	8.28	....	....
"	5*	16.6	15.18	91.4	8.60	....	....

* Progenies 4 and 5 consisted of but one line each and were outside, so are not quite so comparative.

Progenies 4 and 5 having but one outside line each are not directly comparable with the others. But even then in studying the results we find comparatively little fluctuation. The agreement is certainly much closer than if whole stools had been taken for samples.

We next tried individual stalks, taking the primary of each stool for analysis. Although the results vary a little more than the line averages, they are better, we believe, than if the whole stool had been taken.

One such series is given below:

Stool No.	No. of stalks in stool	Weight of Primary	Brix	Juice Test of Primary Pol.	Pur.	Q.R.
1	12	4.7	16.6	15.29	92.2	8.48
2	None	...	....	.....	....	....
3	8	4.0	17.2	15.83	92.0	8.20
4	10	4.1	17.4	16.04	92.2	8.09
5	9	4.1	16.6	15.31	92.3	8.46
6	4	4.0	16.5	14.95	90.6	8.78
7	6	3.8	16.5	15.13	91.7	8.60
8	6	3.8	16.3	15.05	92.3	8.61
9	4	3.9	16.5	15.10	91.5	8.63
10	6	4.3	16.6	15.29	92.1	8.49
11	3	5.1	16.5	15.13	92.7	8.54
12	5	4.5	16.2	14.86	91.7	8.76
13	5	3.9	16.0	14.57	91.0	8.98
14	8	4.2	16.6	15.15	93.4	8.49
15	11	3.1	16.3	14.88	91.3	8.78
Average			16.6	15.18	91.4	8.60

We believe this method offers a practical way to get at the sugar content of our Bud Selection progenies. By working with single eye, (or so-called Cuban seed piece) plant cane, we can go through the area taking the primary of each stool. The rest of the stool remains and can be used for seed later, when the best stools in sugar in the best progenies can be picked.

An interesting test can be conducted along these lines, by taking, for instance, 500 or 1,000 stools. From this, pick the hundred stools with the highest sugar content and the hundred with the lowest. Plant one or two seeds of each alternating, repeating for several crops.

We plan starting work of this nature at Waipio this year.

Growth Measurements

By W. C. Jennings

The subject of growth measurements is being brought up, not as a new idea, but as one which is not receiving the attention it merits. The results derived from the first season of the work at Hawi Mill & Plantation Co., Ltd., have

proven so valuable that we now have visions of seeing most of the plantations, at least the irrigated plantations, eventually coming under some system of agricultural control which will be based on some method of collecting and recording growth measurements.

The purpose of this article is to describe the methods being used at Hawi Mill & Plantation Co., Ltd., where we are already making a practical application of the growth measurement idea to field practices. Before going into the details of the system at Hawi we want to especially emphasize the fact that the conducting of growth measurements does not necessarily mean the employment of trained or high salaried men for the work. Any laborer who can read and write and is in any degree dependable can take care of the time-consuming and laborious part of the work. The checking and recording of the measurements taken by this laborer need take only a small proportion of the time of some plantation office assistant or of some dependable overseer.

Our method of measuring cane stalks is described in detail in the *Record* for October, 1924, by H. K. Stender. Details of investigations and studies as to the reliability of this method are described in the *Record* for July, 1922, and in *The Improvement of Sugar Cane Through Bud Selection* report of 1922 by A. D. Shamel.

In our preliminary experimental work at Hawi, testing this method of measuring cane growth, we secured surprisingly uniform results in tests where measurements were conducted on as few as 30 stalks in a series. One test comparing nine series of 30 measurements each, the results of which were illustrated by graphic curves, gave very uniform results from all nine series, while all the area within the test received uniform treatment.

At Hawi Mill & Plantation Co., Ltd., the general plan is to measure 50 stalks in each field. If the field is planted to more than one variety 50 measurements are taken on each variety.

The locations in the field in which stalks are to be measured always represent, as near as can be determined, average conditions in the field. If a field is very rolling, for instance, and about one quarter of the area is in hollows while the remainder is hills, the measurements are distributed in like proportion, that is, one quarter of the measurements would be taken in the hollows and three quarters on stalks growing on hills. Stalks from stools on watercourses, outside lines, etc., are not measured.

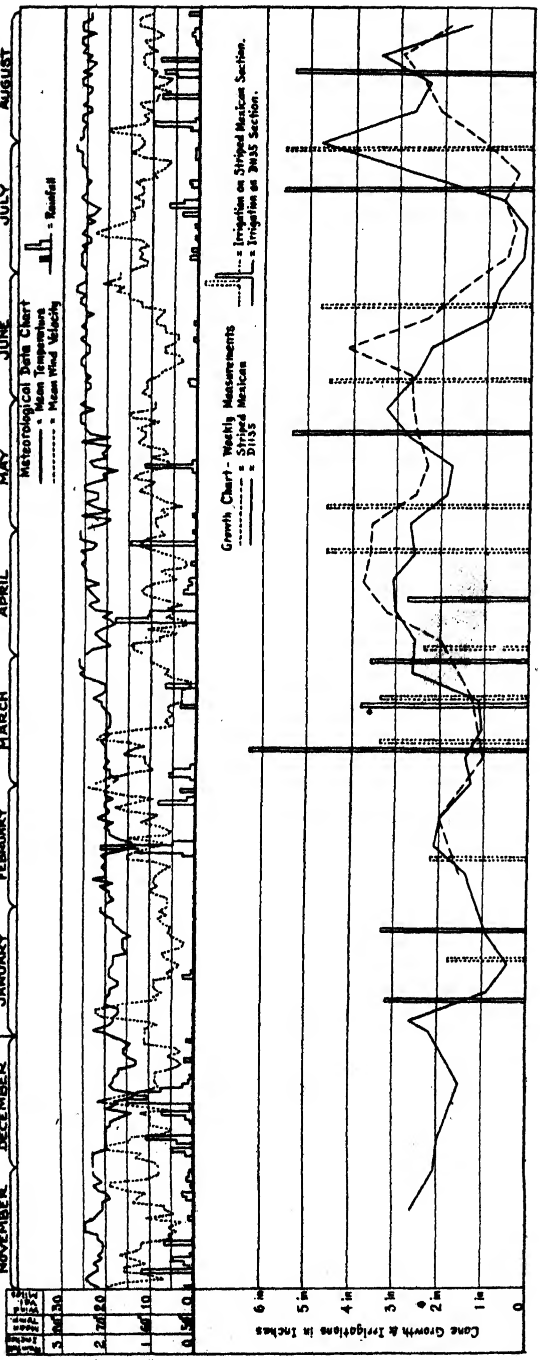
The stalks selected for measurement are marked with Pyroxolin tags giving the stalk number. When animal cultivation is finished in the fields wooden stakes are placed in the middle of the rows near the stalks to be measured. This saves much time in locating the measurements when the cane has closed in. Stakes are also placed around the edges of the field or along the field roads at intervals giving directions for locating the nearest measurements.

Measurements are taken every two weeks on each field. After the stalks have been selected and the first measurement made the work of measuring is turned over to a laborer. Each morning this laborer is supplied with sheets such as the one shown in Table 1 giving the field number, variety and number of the stalks to be measured. These sheets are turned into the office each evening and this

CHART I

GROWTH CHART WITH CLIMATOLOGICAL AND IRRIGATION DATA

Hawi Mill & Plantation Co. Field Haea 5.



data is entered on sheets such as are shown in Table 2 by whoever is in charge of the work.

The work of the man taking the measurements in the field is checked by the person who works out the sheet shown in Table 2. This checking of the honesty and accuracy of the man who does the measuring works out as follows:

1. The measurements as taken in the field are entered on sheet No. 1 and these sheets are turned into the office every afternoon, leaving no record in the hands of the measurer.

2. The moral effect arising from the fact that whoever is working up the data on sheet No. 2 can at any time check up very easily on any or all the measurements turned in at any time, as the stalks are tagged and numbered and easily located, and the person working up the data can always keep the measurer uncertain as to when and to what particular location he may decide to check up on.

The next most important step in the work at Hawi after the collection and recording of this data is the presentation of it in a form which attracts the interest of the field men. This has been done by means of graphic charts. By showing climatalogical data, time and amount of irrigation by graphic curves on the same chart with the growth curves many interesting and valuable correlations between cane growth and these factors controlling growth have been observed.

Chart I shows a chart worked up for Field Hoea 5 at Hawi Mill & Plantation Company, Ltd.

Chart II shows a chart which is also worked up for each field. On this chart a record of all field operations, such as weeding, fertilization, etc., is kept. Each operation is entered on this chart on the day on which the round was completed.

The growth in each field at Hawi is shown graphically as in Chart I. In addition to this the fields are grouped as follows:

1. Irrigated plant cane.
2. Irrigated ratoon fields.
3. Unirrigated plant.
4. Unirrigated ratoons.

A chart is made out for each of these groups. On these charts are shown the individual curves for each field within the group and also an average curve for each group.

In actual practice this system of charting measurement data is proving to be of great value. If after a periodical measurement any particular field shows either more or less growth than the average for the group to which it belongs, an investigation can immediately be started to see why this is the case. The chart shown in Chart I will show to what extent weather conditions may have affected this unusual growth. If the reason is not apparent in this chart we next look at the chart shown in Chart II and see what has been done to this field in the line of weeding, fertilization, etc., or what treatments may have been omitted on this field, which the other fields in the group have received.

It is possible in this way to keep a very close check on what each field is doing. By knowing what each field is doing it is possible to attempt to bring up fields which are dropping below the average for the group, or again possibly to bring all the fields up to a high standard set by some particular field by studying the conditions that have brought about such a high standard of growth.

CHART II

(Cut on dotted lines)

YEARLY PROCEDURE CHART
on a Daily Unit Basis

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
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31													

The layout at Hawi gives every indication that much of the guess work can be eliminated from cane culture by conducting growth measurements and we can learn the effects of different treatments such as irrigation, fertilization, etc., without waiting one or two years for harvesting results.

Summary

1. Conducting growth measurements, even on every field of a plantation need not be very expensive. The time of a fairly dependable laborer who can read and write, and the part time of an office assistant or a field overseer is sufficient to take care of the work.

2. By installing a system of collecting and recording the measurement data, such as is outlined above in this report, an efficient check on the honesty and accuracy of the man who actually measures the stalks in the field, can be maintained.

3. Showing graphically cane growth together with many of the factors controlling cane growth makes it possible to correlate these factors with cane growth and also gives a complete history of each field that can be easily and clearly seen by the field men.

4. By comparing the growth in different fields with the treatments received it may be possible by changes of treatment to bring up fields in which the rate of growth is below the average or to bring up all the fields in the group or crop to the high standard set by a single field.

5. By conducting growth measurements it is possible to determine the effects of irrigation and fertilization almost immediately. When it is necessary to wait one or two years for harvesting, some condition or treatment other than the one in question may complicate the results.

TABLE 1

Field No. .... Crop. ....

Variety .... Date ....

Stalk Number	Length	Stalk Number	Length	Stalk Number	Length	Stalk Number	Length	Stalk Number	Length

TABLE 2

Field Number 9 Irrigated

Variety D 1135 — Crop 1925, 1st Ratoons

Stalk Number	First Length 7/14	Length 7/28	Growth	Length	Growth	Length	Growth	Length	Growth
1	37.1	39.2	2.1						
2	34.2	37.5	3.3						
3	33.9	36.7	2.8						
4	41.2	42.8	1.6						
5	41.7	43.6	1.9						
6	38.3	41.9	3.6						
7	39.6	42.7	3.1						
8	37.8	40.6	2.8						
9	35.4	38.8	3.4						
10	36.7	39.1	2.4						
11	37.4	39.5	2.1						
12	42.1	45.0	2.9						
13	42.3	45.7	3.4						
14	39.6	41.2	1.6						
15	36.9	39.6	2.7						
16	43.2	45.3	2.1						
17	39.5	42.3	2.8						
18	37.3	50.4	3.1						
19	36.5	38.0	1.5						
20	35.4	38.2	2.8						
21	33.6	36.7	3.1						
22	37.5	41.1	3.6						
23	37.8	41.3	3.5						
24	38.5	40.0	1.5						
25	36.3	39.7	3.4						
26	33.7	35.1	1.4						
27	37.8	40.2	2.4						
28	35.8	37.0	1.2						
39	35.5	37.4	1.9						
30	35.4	36.8	1.4						
31	33.8	36.0	2.2						
32	38.7	41.0	2.3						
33	37.5	41.1	3.6						
34	35.4	39.0	3.6						
35	34.6	35.9	1.3						
36	37.6	39.6	2.0						
37	42.8	44.0	1.2						
38	39.2	42.2	3.0						
39	38.7	41.0	2.3						
40	43.6	45.0	1.4						
41	41.2	43.1	1.9						
42	33.6	36.1	2.5						
43	33.8	35.1	1.3						
44	34.7	36.0	1.3						
45	37.9	40.0	2.1						
46	38.6	41.1	2.5						
47	33.7	35.2	1.5						
48	32.9	34.0	1.1						
49	41.2	43.0	1.8						
50	43.4	45.2	1.8						
Total	1885.4	2007.0	121.6						
Average			2.43						

The Fern Weevil

By C. E. Pemberton

A short investigation of the fern weevil situation in the Kilauea region has just been completed. One day was devoted to a survey of the spread and distribution of the weevil and two days to a study of its parasitism by the Australian parasite *Ischiogonus syagrii* Fullaway.

As was expected, the weevil is slowly spreading. It was found from 400 to 600 feet beyond the original infested area, wherever ferns are available. The present distribution could not be mapped out in a few day's time, but no weevils were found at a distance of approximately one-quarter mile or at even greater distances. We need not greatly concern ourselves with the present exact distribution of the weevil, for in a period of ten or twelve years it will have occupied a large area of forest in the Kilauea country. It is present in the Cooke, Giffard, Young, English, and Carlsmith lots, has spread well into the Olaa Forest Reserve above these lots, is across the Volcano Road into the Shipman forest above the Shipman buildings, and has spread in the Hilo direction as far as the Peter Lee lot. As stated above, it was not found as far as one-quarter mile from the first infested area. A careful search was made in the forest lying between the old Crater Hotel grounds and the infested ground, with negative results. This is a continuous forest and the weevil has penetrated only some 200 or 300 feet into it from the lower boundary across the Volcano Road from the Shipman buildings.

The object of the investigation was to determine the extent to which the weevil is being parasitized and controlled by the introduced parasite.

The weevil is very much under control. The ferns in the new territory into which the weevil has spread are not being killed, in general they are not suffering and a new growth of ferns has appeared and is increasing in the original infested area which was burned in 1920 in an effort to eradicate the pest. Weevils are present on the fronds here and there, usually in twos or threes. Ferns bearing a dozen weevils are uncommon, though occasionally one is seen. There is no massing of weevils on any of the ferns, as was the usual thing in 1920. The attack on the ferns on the original ground and in the new territory into which it has spread is now mild. There is no desolation as in 1920 and it seems fully logical at present to conclude that the ultimate spread of the weevil over the entire Kilauea fern-forest area will be of so mild a nature that neither ferns nor native forest growth, dependent on them for ground cover, will suffer.

This reduction in beetle abundance and damage would appear to be solely owing to the activities of the imported parasite, *Ischiogonus*. It is abundant and effective both in the old and new areas of weevil infestation. It is parasitizing the larvae of the beetle at the very limits of its spread. As near as could be determined, the parasitism now amounts to 60.7 per cent. The exact degree of control could only be determined after many weeks of study and the above figure is made only from counts made here and there over the entire infested region. It is based on an examination of 403 channels made by the beetle-larvae

in the fern stems. Growing larvae were not considered, as they might yet be parasitized before reaching maturity. Unparasitized individuals were those larvae which had pupated or matured to beetles and left in the stem the typical emergence hole of the adult. Parasitized individuals were those wherein the borer channels showed the clusters of parasite cocoons, either empty or still occupied, there being 1 cluster per parasitized individual. In this manner I found, in the older fern stems, 158 beetle emergence holes or beetle pupae and 245 clusters of parasite cocoons. Sometimes the cluster in the channel comprised only 2 or 3 cocoons and occasionally only one. The adult parasite wasps were seen hovering about in the ferns wherever the weevil occurred. The parasitism was particularly high among the young ferns springing up in the burned off area. This is because the stems of the young ferns are small and the contained beetle grubs are very easily reached by the sting of the parasitic wasp.

I believe the recent ash eruption of the Kilauea Volcano has temporarily interfered, to some extent, with the efficiency of the parasite. The entire forest, for several miles around, was coated with this ash and formed a mud-like layer over most of the fern stems. This must interfere a good deal and prevent the female wasp, which is small and delicate, from properly ovipositing on many of the weevil larvae lying within the coated fern stems. I am indebted to Mr. W. M. Giffard for advance information respecting this. However, if there has been such a check, it was only temporary, for the parasite is now actively operating. This mud still remains on the stems. Over the entire area covered by this eruption and particularly where the ferns are shaded and tender, much of the growth is broken and dead from the weight of the accumulated mud-like ash. Tender fronds have broken in halves, the outer half hanging dead. The tips are likewise hanging dead on many of the ferns and often whole fronds have fallen over and withered from the same cause. When entering the weevil-infested area one would first ascribe this damage to the insect, but examination soon shows it to be otherwise, particularly when the uninfested area is visited.

Welding As a Reclaiming and Manufacturing Factor*

By Arthur G. Cooper

There are several commercial processes of welding worthy of mention, but, as only three of these are being used in Hawaii, the purpose of this paper is to partly cover the field of application of these three processes. They are, according to their respective fields of application, Electric Arc, Oxy-Acetylene, and Thermit.

Electric Arc: There are two kinds of electric arc welds; the metallic arc process and the carbon arc process.

On account of its simplicity and general superiority, the metallic arc is more generally used. The physical characteristics are, however, quite similar. The

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

physical characteristics of both are determined chiefly by the perfection of fusion between the pieces of metal to be united.

The metallic process is more readily examined to determine its degree of fusion. This is usually accomplished by breaking the arc while welding is in progress and observing the depth of the crater. The operator may also observe the depth of penetration while welding is being done and judge as to quality of the weld. The only exception to this, however, is when a current of too great a density for the welding electrode or the thickness of the metal being welded, is used. The importance of this cannot be too strongly emphasized when breaking in a student welder, as the strength of the weld depends largely on the current density for various size electrodes. The following table represents the approximate values of arc current and electrode diameter for various horizontal plate thicknesses used by the leading manufacturers and repair shops:

Thickness of metal	Amperes Arc current	Electrode diameter
1/8 inch	50—75	1/32 inch
1/4 "	85—125	1/16 "
3/8 "	125—150	3/32 "
1/2 "	125—175	1/8 "
5/8 "	135—185	5/32 "
3/4 "	150—200	3/16 "
7/8 "	175—225	3/16 "
1 "	175—250	3/16 "

The overlapping and welding of two plates of the thicknesses given in the above table, however, will necessitate increasing the arc current and the electrode diameter due to the increased thermal capacity of the two sections. In lap welding two such sections, the current should be approximately 100 per cent higher. After the required current has been obtained, the electrode diameter should be increased. The required size can be found by referring to the above table for electrodes corresponding to various currents.

The electrode material is also an important factor. To prevent unfused areas from occurring in the weld, it is necessary that the fusing temperature of the electrode should exceed that of the metal to be welded. Pure iron has a very high melting point, but, due to its high affinity for oxygen in its vaporized form, excessive oxidation occurs, resulting in an inferior weld. The use of an electrode with a lower melting point than that of the metal to be welded results also in an overlap resulting in unfused pockets underneath the deposited metal.

There are numerous ways of determining the character of a weld. The factors which determine the physical characteristics of a metallic arc weld, however, are fusion, slag content, porosity and crystal structure.

A visual examination of a weld may be made to determine the surface finish indicating the operator's regard for good workmanship, length of unbroken deposits, indicating ease of operation and ability to control the arc; uniformity of deposit indicating faithfulness of operator in depositing metal in its required place; proper fusion of metal at bottom of weld as shown from bottom of weld; amount of surface porosity and slag indicating either of three things, machine of inferior design, unsuitable electrode or improper preparation of metal.

The applications for electric welding are many and varied, but, principally to repairing and manufacturing ferrous metals. It is believed that anything made of steel can be repaired by the electric process, considering, of course, the ultimate strength any electric weld would have when made under favorable conditions as compared with the strength of the parent metal. It should also be remembered that electric metal that has been deposited through an electric arc is no longer a piece of rolled steel but cast. The natural thing to do, is to make our finished welds possess as near forging characteristics as possible, especially where the amount of deposit is limited for lack of space.

The approximate speed of electric arc welding is given in the following table:

Plate thickness	Speed of welding in feet per hour
1/8 inch	30
3/16 "	25
1/4 "	20
1/2 "	4

In general, an estimate can be made allowing 8 to 10 cubic inches of deposited metal per hour using a current 175 amperes and an electrode of 5/32 inch.

The cost of electric arc welding will average about 3 to 1 in favor of the arc over gas, except on sheet steel of 1/8 inch or less.

Gas Welding: The French must be given credit for producing the first commercially successful oxy-acetylene blow pipe or torch, about 1901. The torch is in reality the heart of the gas welding system, as it must function to supply the oxygen and acetylene at the proper rate to produce a flame for satisfactory welding. The combination of oxygen and hydrogen is also used for gas welding and cutting.

When welding with the gas torch the flame is directed against the material to be welded. The filler material in the form of a rod is also held in the flame, which causes it to be melted and unite with the molten portions of the material. The proper adjustment of the gases must be made so that the flame will be neutral and not oxidizing.

The oxy-acetylene flame is not intrinsically as hot and the heat is not nearly so concentrated as that of the electric arc. For this reason, the chief welding field for gas at present is that of the sheet metal of less than one-eighth inch in thickness and for non-ferrous metals. If the joint must be very smooth, the gas process will undoubtedly give superior results in the long run. There is also less tendency to burn the metal when working with thin material, this being due to the fact that the gas welding flame produces a lower temperature. Since the gas flame is not as hot and concentrated as the electric arc, the time required to perform a weld in thick material is in the ratio of 2 or 3 to 1. This condition together with spreading of flame, results in much trouble due to expansion and contraction of mild steel plates. The actual difference in cost of gas and arc welding had been found by some investigators to be as high as 3.1 in favor of the arc, taking all charges into account.

Based upon statistics obtained from various sources, it has been found that the cost of welding 1/8 inch plates is about the same for gas and the arc. Plates

1/4 inch thick can be welded by arc for about half the cost of gas welding. For plates 1/2 inch thick, the arc cost will be from 25 per cent to 15 per cent that of gas. These figures are based upon total costs of doing the work.

The oxy-acetylene process is subject to the same criticism as the carbon electrode process, namely, that it is possible for a careless or inexperienced welder to melt the filling material too rapidly, thereby causing it to flow over unfused surfaces of the work, which produces a weak weld. In the hands of a skilled operator, however, thoroughly satisfactory welds can be executed.

In the field of cutting, the gas flame, although more expensive, is preeminently the better for cutting mild steel plates, angles and shapes. For this work, a special tip is used, which reduces the acetylene to a minimum sufficient to support the flame, whereas the oxygen is supplied in greater quantities. The action produced is that of oxidization or burning, which takes place very rapidly, with the removal of a minimum amount of material. The action is the same as that of the familiar physics experiment wherein a piece of watch spring is heated to a red color in a Bunson flame, after which it is dropped in a bottle of pure oxygen, whereupon the spring is rapidly consumed, accompanied by a rather spectacular pyrotechnic display. Cast iron, however, contains such a large percentage of carbon, both combined with iron and in the free state, that the burning process cannot be used. The metal must be actually melted and, therefore, the electric arc is faster than the gas, owing to the difference of the intrinsic heat values.

Thermit Welding: The Thermit process of welding differs principally in the rate of application and the removing to a great extent of the personal element. According to different engineers, this comprises about 90 per cent of the efficiency of the other two processes. Any progress made in the removal of these elements naturally will result in welds that more nearly approach 100 per cent efficiency. The personal element is, to a large extent, eliminated from the Thermit process, inasmuch as the various involved steps in making a weld are in a measure changed to mechanical operations that are under control of the operator.

The making of a Thermit weld will not be gone into in detail here.

The field of application for Thermit welds differs slightly from the other two processes in that it is particularly applicable to pipe work, rail welding and more especially large sections, such as roller shafts, pinions, locomotive frames, marine repairs, crank shaft repairs, etc. In fact, the field of application very seldom overlaps.

The tensile strength of a Thermit weld exceeds either the electric or gas due principally to expansion and contraction taking place in the whole welded mass simultaneously and the exclusion of oxidized portions. It is a physical impossibility to eliminate shrinkage strains by applying only small portions of molten metal and allowing this to cool in the same manner. We are also unable to prevent oxidation completely. This obviously eliminates gas or electricity where it is possible to use Thermit, especially when a weld should be as near perfect as is possible to obtain.

Report of the Committee on Irrigation*

By Frank W. Broadbent

In presenting a report on the subject of irrigation, the objects have been, first, to follow up points mentioned in last year's report but upon which data was not available at that time; second, to make notes of such items of progress on which it has been possible to secure information, and finally to suggest a few topics upon which we might have a general discussion.

Hawi Overhead System

It was sugested in last year's report that there might be trouble after a while with the sprinklers clogging, due to the accumulation of rust, dirt, etc., in the pipes. Manager Hind writes, however, that in the installations that have been in operation for seventeen months no trouble with clogging has occurred.

At Hawi they have found that 1½ acre inches per week of overhead irrigation is sufficient for maximum growth in young cane. With older cane about 3½ inches every two weeks is necessary. A study is being made as to just what age the change should occur. Another study that is being made is on soil moisture and growth measurements, resulting from overhead irrigation as against the same resulting from irrigation applied by the usual contour system. Mr. W. C. Jennings is carrying on these investigations.

No major improvements have been added to the Hawi system, but they have come to the conclusion that with the size pipes they are using on the laterals the length should be no greater than 450 feet. (These lateral pipes vary in size from 2 inches down to ¾ inch at the far end.)

Orchard System of Irrigation

Kilauea Plantation reports that they have nothing new to offer on the Orchard system of irrigation that has not been presented in previous reports.

At Koloa Sugar Co. an experiment using the Orchard system was harvested this year. Another will come off in the 1925 crop. Of the 1924 test Manager Moir does not feel that the results are such as to permit of any decisive comment. The following interesting notes are made, however: (1) That the Orchard system yielded about 1½ tons cane per acre more than the contour system. (2) That this higher yield is offset by the fact that the Orchard system received eight full irrigations for the crop as against three for the contour system. (Note: This test was laid out in a mauka semi-irrigated field.) (3) That the cost of laying out an area is cheaper per acre than it is for the contour system. (4) That the distribution of water by the Orchard system is not effected as evenly as it is possible with the old system.

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

The test for the crop of 1925 at Koloa Sugar Company is laid out in one of the steadily irrigated makai fields of H 109 cane. Measurements have been kept of the water used by each system, and to date it is found that the Orchard uses from 20 to 25 per cent more water per irrigation per acre than the contour system.

From Ewa Plantation Company it is reported that the test of the "no water-course" or Orchard system is being continued in ratoons with the object of obtaining more data on yields before conclusions are drawn. The system here is noted as a labor saver and as not requiring more water than the regular Ewa system.

A test for the 1924 crop, comparing the Orchard system, Peru system, and 32-foot and 40-foot watercourse of the regular contour system, has been running at the Oahu Sugar Company, Ltd. Interesting figures on the water consumption of each system were presented in last year's report.

Baldwin Flume System

The Baldwin flume system is being tried out at the Maui Agricultural Company, Ltd., by Mr. H. W. Baldwin, the originator. A layout of 150 acres is to be harvested in the 1925 crop.

Ditches

Pioneer Mill Company, Ltd., has in the last year lined 2½ miles of the Honokahau Tunnel with concrete. This lining is put in with forms, is 4 inches thick and has no reinforcing. The inside dimensions are, depth 4 feet 6 inches, width at top 6 feet, and width at bottom 4 feet 3 inches. It is designed to carry 50 million gallons per 24 hours.

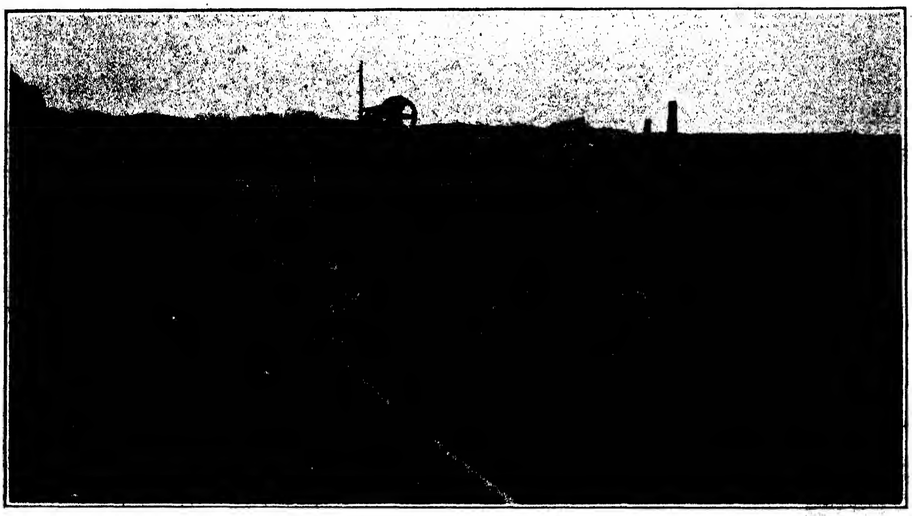
The Hawaiian Commercial & Sugar Company have re-dug and concrete-lined approximately 2 miles of their Camp 7 ditch. This is a 21-million gallon ditch. The top width is 7 feet 11 inches, bottom 2 feet 5 inches, and depth 3 feet; grade 5 feet per thousand.

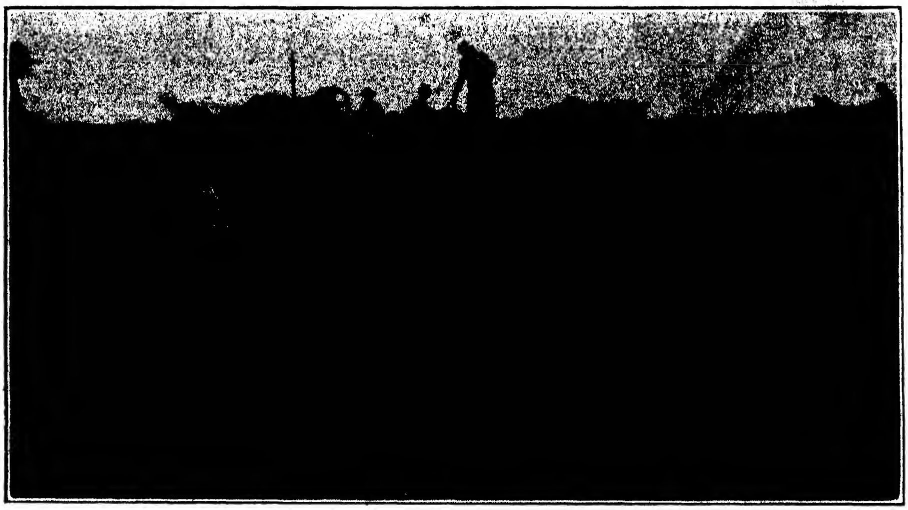
The method of pouring concrete lining in this work is quite interesting. The main points are described in W. P. Alexander's bulletin *The Irrigation of Sugar Cane in Hawaii.* To quote: "A 3-inch concrete is placed without forms on the ditch banks, which have a 1 to 1 slope, and likewise on the ditch bottom; the concrete is followed up immediately with a plaster finish * * * The plastering being placed immediately upon the unset concrete bonds with it perfectly * * * We find it necessary to place expansion joints every 15 feet in this 3-inch lining. If farther apart, expansion and contraction, due to changes in temperature, have caused cracking. We use no reinforcing in this concrete. Probably the expansion joints could be placed further apart if reinforcement were used."

The concrete used is mixed quite stiff and consists by volume of 1 cement, 2½ sand and 4 rock. The plaster is the same less the rock. The mixing is done in a "Rex" mixer mounted on a movable platform which is shoved along as the work proceeds. The following series of photographs show the details of operation more concisely than can be described. Sixteen men form the mixer

crew and one 15-foot frame per man per day, or a total of 240 feet, is the regular rate of work. The finished job presents a very neat ditch and evidence of lasting qualities is to be seen where such ditches have been in use for several years.

The Wailuku Sugar Company's pre-cast concrete slab-lined ditches are standing up well. Note the sweet potato vines and pigeon peas growing along each side, thus saving hoeing and keeping weed seeds out of the irrigation water.

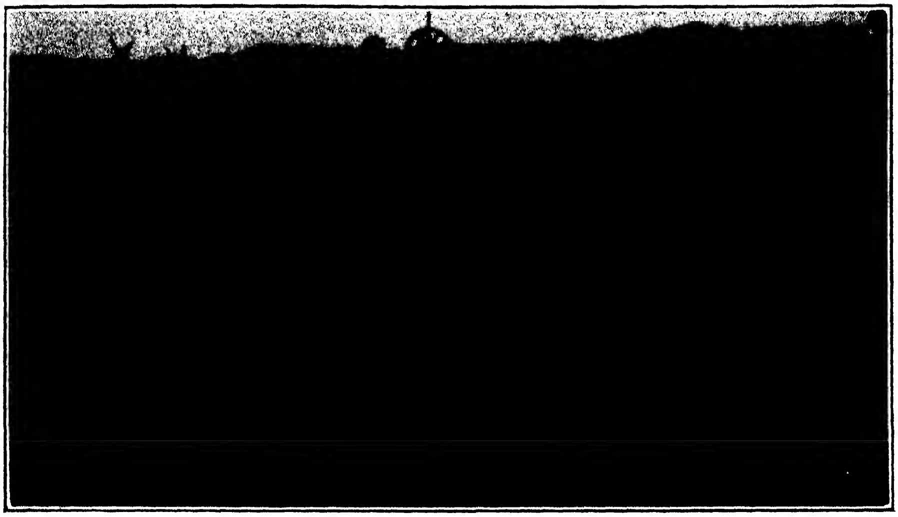




CONCRETE DITCH LINING AT HAWAIIAN COMMERCIAL & SUGAR CO.

Above: General view of the outfit used. The 2" x 4" stringers along each edge of the ditch are the only forms used in this work.

Below: Three men trim sides ahead of mixer, put edge forms in place and lay tar paper for expansion joints. Five men supply materials from cars to mixer skip. Two men operate mixer. Two men shovel concrete up on ditch sides. Two men tamp concrete. One man smooths off plaster. An expansion joint is placed every 15 feet

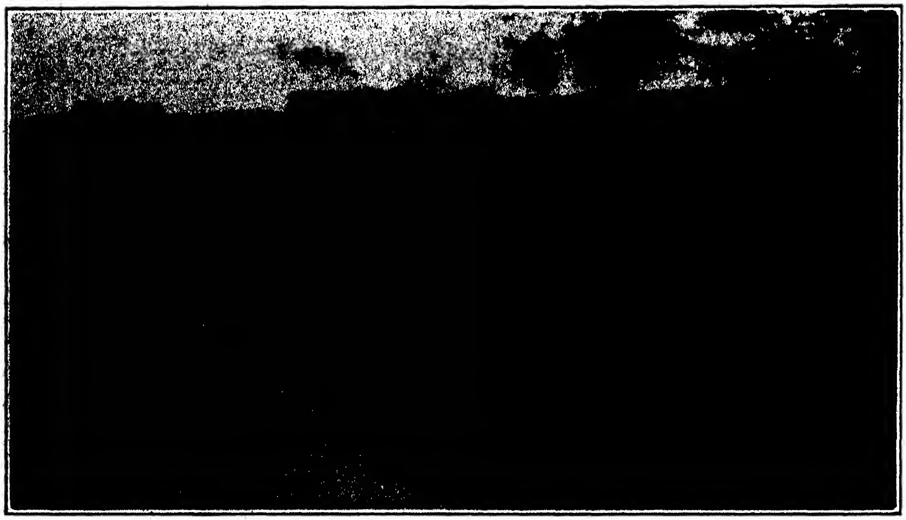


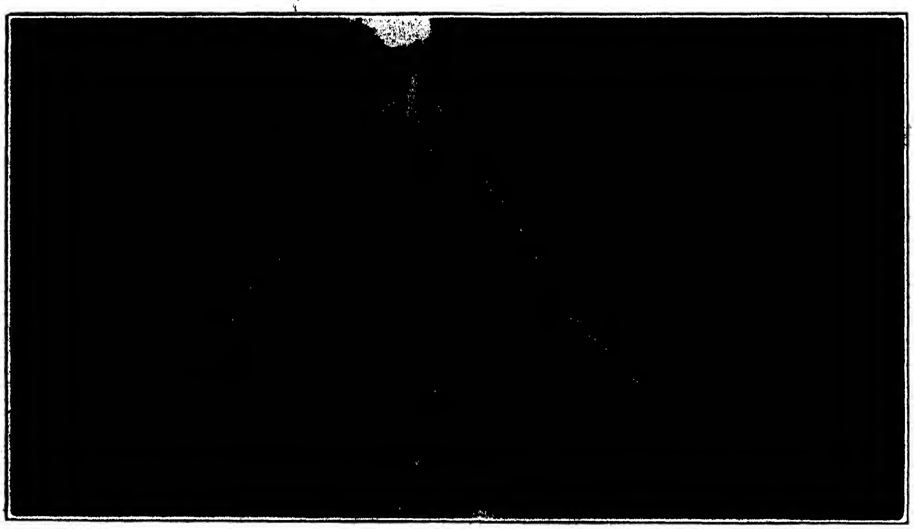
CONCRETE DITCH LINING AT HAWAIIAN COMMERCIAL & SUGAR CO.

Above: The mixer is run along on planks, as shown in the foreground. A one-cylinder "Novo" engine furnishes power. The hose at the right leads from the engine-driven pump to an old ditch from which water is obtained.

Below: Applying the plaster finish immediately after the concrete has been placed. One man stays behind and does the smoothing off while the concrete work proceeds.

Lining by means of cement plaster on chicken wire reinforcement is no longer practiced on Maui because of unfavorable results gained from previous work. Such lining gives way and cracks easily because of its thinness and unevenness of application to the ditch sides.





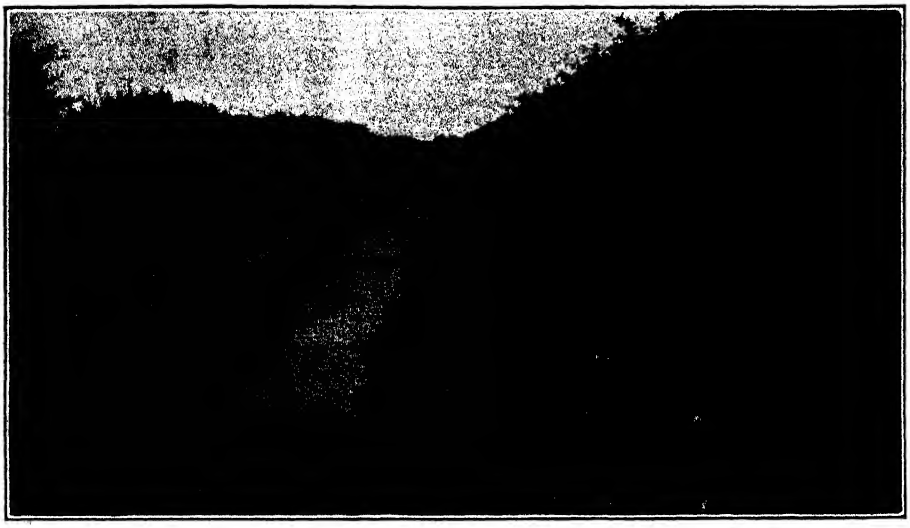
Concrete Ditch Lining at Hawaiian Commercial & Sugar Co.

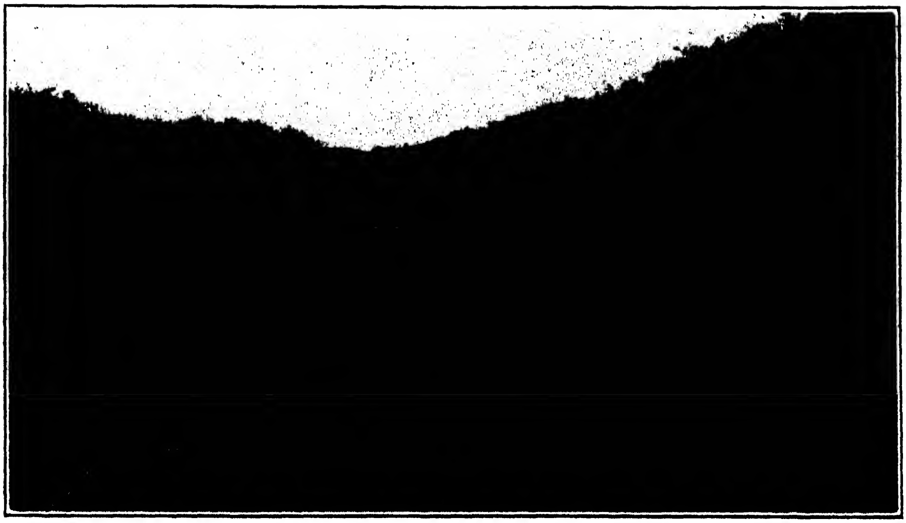
Above: After the previous day's work has set over night, one man applies a coat of waterproofing cement wash with a whitewash brush.

Below: A section of the finished ditch.

Water Measurements

Increased interest in water measurements is manifested by the growing number of measuring devices used in the Islands. The Great Western Meter Company reports the sale of 232 Lyman meters here, the East Kauai Water Company, Ewa Plantation Company, Hawaiian Homes Commission and the Waimanalo Sugar Company, being supplied with the greatest number of meters in the order named.





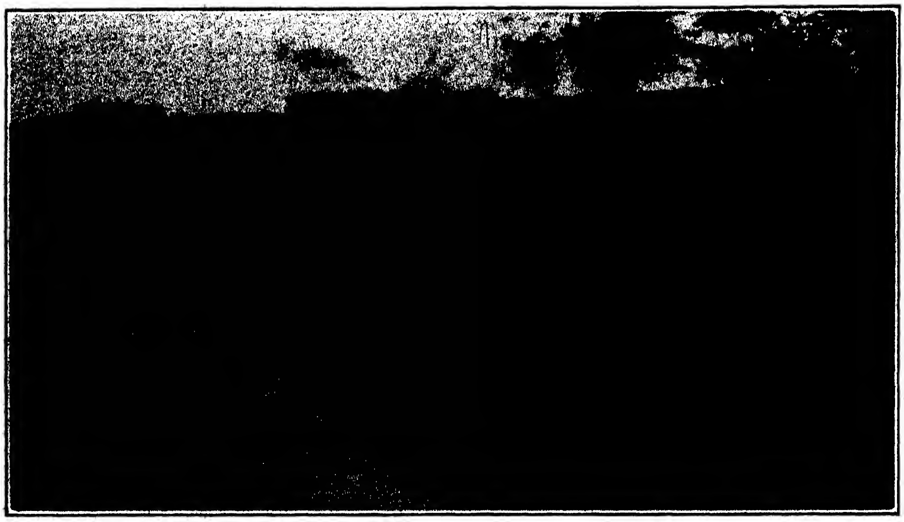
WAILUKU SUGAR COMPANY PRE-CAST CONCRETE SLAB-LINED DITCH

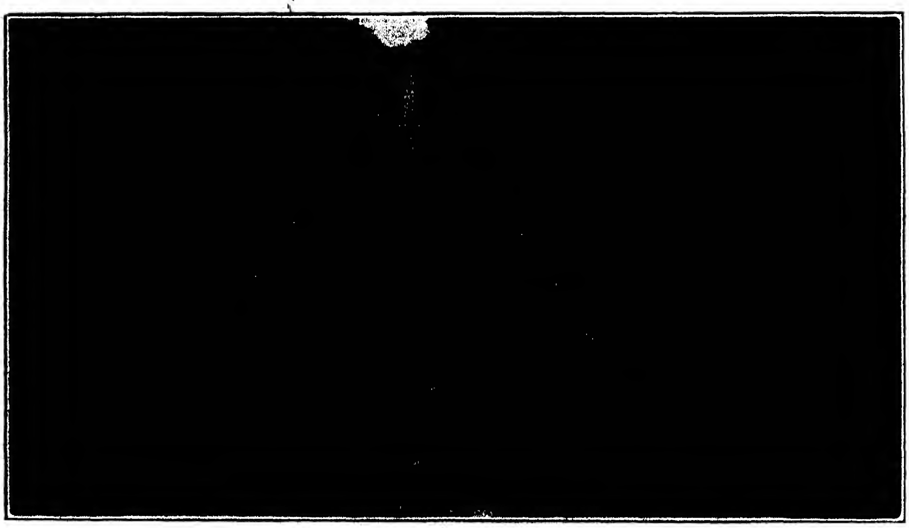
These two photographs show a section of cast concrete slab-lined ditch that has been in place for four years. Other sections that have been in place for an additional two years look as well.

At Hawi Mill & Plantation Company, Ltd., several of these meters are in use in conjunction with the sprinkler system and have been found accurate and handy.

Mr. John M. Watt, who is in charge of irrigation investigations at Ewa Plantation Company, reports as follows:

This meter (Great Western) is not an expensive machine in comparison to other measuring devices in operation for this work. The original outlay is moderate, and upkeep is practically nothing. It is fool proof and so requires little attention aside from





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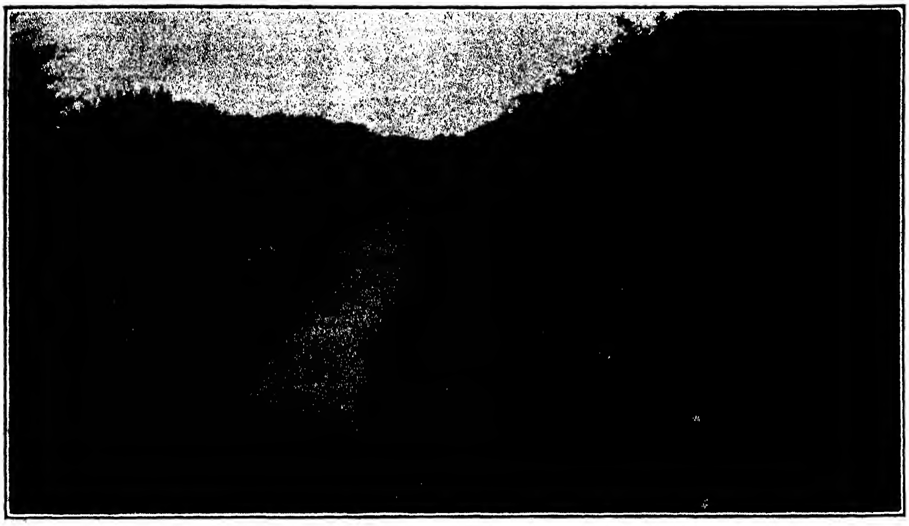

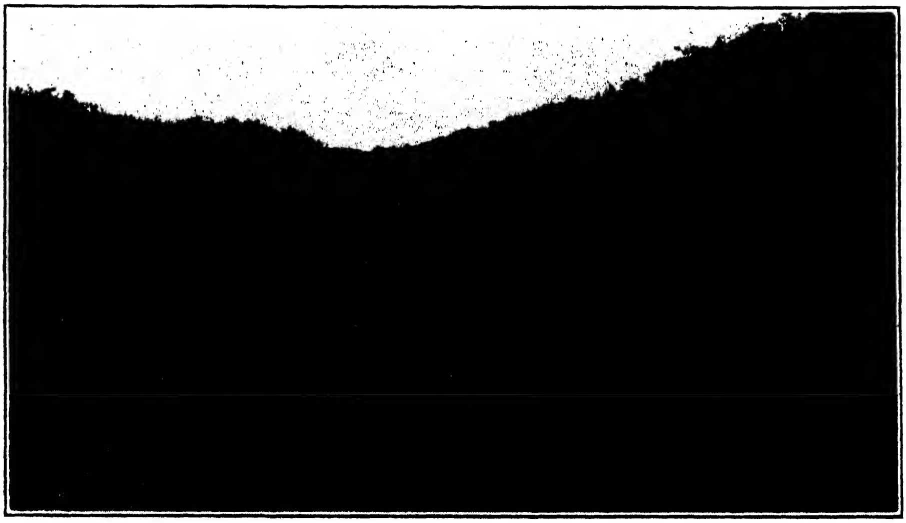

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daily readings and also seeing now and then that it does not become fouled * * * We have found that the cost of installation of meter structures is very reasonable * * * One carpenter and a helper can make from two to three of these structures in a day. Two men can install from one to three structures a day in the field, depending on the nature of the ground they are working in.

Mr. Joel B. Cox, of the McBryde Sugar Company, writes:

We are using Stevens Water Stage Recorders extensively in our water measurement work here. For ditch measurements we have adopted rating stations equipped with the Type E-Recorder. As no weir or submerged orifice is used, the total cost of the installation is the least of any available method, and in many cases the additional labor in working up the records is offset by the value of having a complete graphical record of the flow, which cannot be obtained with such a device as the Great Western Meter. We have found the Type E-Recorder very satisfactory in operation. The cost is a little over $60 per instrument.

Another type of meter that is being tested at Waipio is the "Reliance." This make differs from the usual run of meters in that all of the water measured passes through the instrument.

Mr. Cox has done some work in correlating yields of different varieties with amounts of water used on the same. Plotted curves show that H 109 yields highest, D 1135 next and Yellow Caledonia third from a given quantity of water under McBryde crop conditions.

At Waimanalo Sugar Company, a very interesting series of tests are being carried out correlating water measurements and cane growth. This work is not an end in itself, as it was desired to obtain information as to the "maximum amount of irrigation water which the plantation could use and produce an adequate return in the production of additional sugar."

A report of the earlier stages of this work is to be seen in the *Record* for April, 1924. Since this report additional work has been done, and it is hoped that we might hear of this at this time from Mr. Stewart.

Pumping Plants

Small pumping plants are in use on several plantations, either for supply or drainage purposes. Fairbanks, Morse Semi-Diesel engines are found to be suitable power units for these plants. There are some eighty of these engines in operation in the Islands and Mr. F. E. Richardson, local agent, offers the following information on certain installations:

The Fairbanks, Morse Engines are two-cycle solid injection of the Semi-Diesel Type and are guaranteed to develop their full rating on 46 pounds of oil per horse power hour at full load.

Kekaha Sugar Company, Ltd., has two 75 h.p. Fairbanks, Morse Semi-Diesel Engines, each driving an 18-inch Type 800 Splitcase Fairbanks, Morse Pump delivering 10 million gallons of water per 24 hours against a total head of 26 feet. Each engine is operating on 5 gallons 24 gravity fuel oil per hour, total 120 gallons per 24 hours at 5 cents per gallon or a total cost of fuel of $6 per 24 hours. Lubricating oil at $1.50 per day makes a total of $7.50 for 10 million gallons, making the cost of water pumped about 75 cents per million gallons excluding labor.

These two plants when operated together pump 20 million gallons with one day and one night engineers.

We recently installed at Kekaha a 150 h.p. Fairbanks, Morse operating a 12-inch centrifugal pump having a capacity of 6 million against a total head of 98 feet.

This engine consumes 10 gallons fuel oil per hour and $3 worth of lubricating oil per 24 hours, making the cost of operating for 24 hours $15 per day or at the rate of $2.50 per million gallons.

Kekaha Sugar Company has two 75 h.p. Fairbanks, Morse Type "Y" engines in their Mana section, driving two 18" Fairbanks, Morse Splitcase Figure 800 Centrifugal pumps. Each pump delivers 10 million gallons of water, making 20 million against a head of 26 feet.

Waianae Company has eight Fairbanks, Morse engines in operation ranging from 75 to 10 h.p.

In regard to the engines at Waianae Company, Manager Brecht states:

A 4-inch pump run by a 15 h.p. Fairbanks, Morse Semi-Diesel engine, pumps about half a million gallons of water 60 feet high.

Consumption of fuel oil is, roughly speaking, 2/3 of a gallon per hour for a 15 h.p. engine, the price of fuel is 5 cents per gallon.

This amounts to a cost of $1.60 per million gallons.

Drainage

A 58-acre field at Ewa Plantation Company is laid out with some 12,000 feet of tiled drainage. That interesting results are being obtained here is to be seen in the following paragraphs from Mr. W. P. Alexander:

The tile drainage system at Ewa has been in operation for fifteen months. During this time a complete control has been had of the amount of water applied to the cane, and the amount of and analysis of the drainage water discharged by the tile. Until the crop has been brought to maturity, it is possible to answer any question in a very preliminary manner only.

(a) Harvesting data will show whether the drainage of sugar cane land by means of tile is profitable. The "acid test" will be a comparison of the sugar yield obtained with the tile with former yields.

(b) There is good evidence that salt which has accumulated in the soil over a period of many years, is being reduced. Fifteen months ago the drainage water contained 80 grains salt per gallon and at the present writing it analyzes 50 to 55 grains. At the time of heavy rains the salt content of the leachings has gone as high as 100 grains. Calculations of the salt content with the amount of water leaving the field in the tile shows that to June 30, 1924, 71 tons of salt had been removed from 58.3 acres.

(c) With cooperation of the Experiment Station, the leachings have been analyzed for the three main plant foods, which are applied as fertilizers. The purpose of the investigation was to determine how permanently fixed in the soil of this type are nitrogen, phosphoric acid and potash. Here was an opportunity to accomplish on a field scale with sugar cane what has previously only been tried out in a laboratory with lysimeters. The results have a very practical application in regard to fertilizer practices.

Phosphoric acid was sometimes found in "traces," but usually not at all.

Nitrogen in the nitrate form was present in minute quantities. The amount of nitrate nitrogen leached out through the tile in 12 months came to 10.87 pounds per acre or less than 5 per cent of the total nitrogen applied as fertilizer.

Potash seemed the least fixed in the soil. The drainage water always contained some K_2O in very small amounts. When calculated on an acre basis, however, the leachings of potash were not large, representing about 10 per cent of the total potash applied to the field as a fertilizer.

Discussion Topics

Have we any further data as to what the optimum length of and space between furrows should be?

What angles should the furrow make with the watercourse, right, acute, or obtuse?

When should dirt be pulled out of the line, after closing first water or second water?

Is the practice of cutting lines ("moku" system) very general? What are the reasons for using this system? When it is practiced, at what stage of the cane's growth should the cut be made in the line?

Any further data on optimum number of lines between level ditches?

Should lines be laid out level or with some grade? If the latter, how much?

To what extent is every-other-line irrigation carried on when short of water? Where practiced, is it confined only to hilled-up ratoons, or to all canes? Where practiced, what is the type of soil, i.e., is it loose and porous or finely divided and easily packed?

Do you save water by irrigating every other row or not (is it not possible that more water is put into the row with this method)?

If, say with 5-foot lines, there are arguments in favor of spacing seed, would it not be just as effective to plant close in the lines and to space the lines further apart? With a less number of lines, there would be a saving of water, etc.

Is it preferable to put in watercourses with the bottom level with the bottom of the line, or with the watercourse bottom above that of the line and with the sides built up?

Where should the trash pani be placed in the watercourse with respect to the furrow?

Where should the cut in the watercourse be made for first water? Where for second and subsequent waters?

The usual method of irrigation, where the single line method is used, is down the watercourse one round and up in the next round. At Hawaiian Commercial & Sugar Company, the watercourse is worked in both directions in each round. Is this practice carried on elsewhere?

What grade should level ditches have?

Is it more economical to make long levels and few straight ditches or the reverse?

Is it better to use reservoir water as the canes need it or to hold it back for expected dry months with seepage losses?

What varieties really are the most drought resistant? Does H 109 take more water or does it curl its leaves merely as a protective measure?

In a shortage of water would you use what is available on the 1925 or the 1926 crop?

In the dry season how many million gallons per day can be counted on by units of acres on the various plantations?

Are the benefits of (1) poepoe, and (2) hilling-up direct in that they actually boost the cane along or are they indirect in that they help to make irrigation, etc., more efficient?

Considering unsoaked seed, what should be the interval of time between first and second water? Second and third? Third and fourth? Fourth and fifth?

Does soaking seed save an irrigation and if so what is the effect on the length of time between irrigations? What is the optimum length of time to soak seed?

After which irrigation should contracts be started?

Is it good practice to irrigate more than one watercourse per man, starting with the second water?

If irrigating ratoons or big cane by men other than the cultivation contractors, what is the best basis of pay in order to get a good job done by the acre, number of lines or day work?

What is the primary basis of the distribution of the water supply over a plantation? This first distribution of the total water is a vital matter on an irrigated plantation, and whatever the basis is, how certain are we of the correctness of our present practices? Should not more effort be directed toward obtaining results which will enable this first distribution to be based on definite facts rather than on opinion and guess work?

Plantation Electrical Equipment*

By E. Butler Smith

This subject, as outlined by the Chairman of the Engineering Section of this Association, is rather broad and could be made to cover practically all phases of electrical work found on a plantation. The use of electricity is becoming so general on Hawaiian sugar plantations that it does not seem necessary to make any plea for its use. The only job that has been left exclusively to the steam engine is the crusher and mill drive. Successful motor drives on the mills and crushers have been installed in other countries and may be eventually tried here. I shall, therefore, include the choice of a mill drive in this paper.

Electrical Equipment for Cane Sugar Factories

The first item that must be considered in any new electrical installation is the type of motor to be used. Assuming that we are not limited by an existing generating plant, the first choice is alternating current, three phase, 60 cycles, 440 volts. Direct current motors would have certain advantages in many cases but the expense of maintenance of D. C. machines and the difficulties in transmission of direct current power in large quantities far outweigh these advantages. The three-phase circuit is the simplest to wire and has the greatest possibilities as far as transmission is concerned. Sixty cycles is the most popular frequency for general use in the United States, which means that 60 cycles apparatus is most readily obtained. We select 440 volts as the highest standard voltage with which we can use standard low voltage wire and knife switches and fuses. The question of switches and fuses will be considered later on.

There are two types of motors to select from: induction motors and synchronous motors. The induction motors are either squirrel cage or wound

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

rotor. The squirrel cage motor is the cheapest and simplest, is least affected by dust and dirt and requires the least attention but has the disadvantage of poor starting characteristics and inconstant speed. This is the type that should be used wherever possible. The wound rotor motor costs more, requires a more complicated control, having slip rings and brushes, is troubled by dust and dirt and requires more attention. It has the best starting characteristics and can be used for variable speed drives. Both of the above types of motors have the disadvantage of having a power factor of less than unity which falls off rapidly when the motor is underloaded.

The synchronous motor requires the most complicated control, more maintenance and care in operation but has the advantage that the power factor is controllable and may be so designed and operated as to a leading instead of a lagging current. A synchronous motor operating with induction motors can be made to take a leading current and thus correct for lagging current taken by the induction motors. This will allow the generating station to operate under more favorable power factor conditions than would otherwise be possible. A synchronous motor to be of much use for power factor correction should have a constant load. If the load varies field adjustment becomes necessary and adds to the expense of operation by requiring constant attention. There are two places in a mill where a synchronous motor may be installed to advantage: on the circulating pump and on the vacuum pump.

Personally, I would not advise the installation of a synchronous motor unless it can be shown that a considerable saving will result in the generating plant or transmission system. Where power is purchased from central station companies a considerable reduction in rates can often be obtained by the installation of synchronous motors, but where the generating station is located in the mill, as is usually the case in these Islands, I do not think that a synchronous motor is justified.

This leaves for general application only the two types of induction motor. Since the squirrel cage motor is the cheapest, simplest and most free from trouble it should be used wherever possible. Wherever constant speed and low starting torque are required the squirrel cage motor will prove most satisfactory up to one hundred horse power. For sizes in excess of this, I believe that wound rotor motors should be used because of the lower starting current. For centrifugal pump drives I think the limit should be set at fifty horse power.

For driving a Searby shredder the wound rotor motor is best suited. Here we require a large starting torque. The load fluctuates considerably depending of course on the evenness of the feed. Since the shredder is provided with a flywheel and has considerable flywheel effect in itself the motor chosen should be of such size as to handle the average load with a fair margin of safety. The puniary switch for this motor should be an oil switch with overload relays having an inverse trine setting. The secondary control should be of the enclosed drum type as this type is more easily protected from dirt and dust.

For a motor drive for the crusher and rolls the wound rotor motor is selected because we require high starting torque and variable speed. The full required speed variation can be obtained by secondary resistance control. There are,

however, certain disadvantages found in this method. At reduced speeds the motor efficiency drops off rapidly due to the large amount of resistance used in the secondary. The resistance grids or water rheostats must be very large in order to dissipate the large amount of heat generated at reduced speeds. Furthermore, with a high resistance in the secondary, the motor speed is unstable. This method has the advantage that it is the simplest and easiest to install and operate.

If the resistance speed control method is not satisfactory the variable frequency method can be used. In this method a separate generator and prime mover is used to supply power for the mill drive. The governor on the prime mover is designed for sufficient speed variation to take care of the speed variation required in the operation of the mill. The desired speed variation between mills and starting is taken care of by resistance control. By this method the resistors can be made much smaller and there is less loss of efficiency due to heat generated in the resistors. The prime mover governor would be motor regulated and the control switch placed on the mill operating platform. As soon as the relative speed between mills is adjusted the speed of the whole train can be raised or lowered by operating the governor motor switch.

For mill motor secondary control the liquid rheostat will prove most satisfactory. In the first place the control can be made as close as desired as there may be any number of steps. Furthermore, there are no contacts to become loose, heat up, and otherwise give trouble, and there are no hot grids to get covered with dust and catch fire.

For puniary control of the mill drive motors, oil switches should be provided with a slow time setting, or better yet, a thermal relay. Oil switch and rheostat control should be so interlocked that it is impossible to close the oil switch until the rheostat control is brought to the starting position.

For the cane carrier drive a wound rotor motor with extra large resistors for variable speed service will be required. A drum type controller should be used which should contain the puniary switch as well as the secondary rheostat switches. With this type of control the operator has only one lever to handle and the starting and stopping of the motor is made easy and convenient.

The remainder of the drives in the sugar factory can ordinarily be handled very nicely with squirrel cage motors. Motors of 5 h.p. or smaller can be thrown straight across the line and require only a safety starting switch for their control. Motors larger than 5 h.p. should be provided with starting boxes of the auto-transformer type, and should be protected by relays.

One of the most important things to be considered in the electrical equipment of a sugar factory is the electrical distribution system and the protective devices.

All wiring should be run in conduit, and the conduit should be laid out so that it does not come too close to steam pipes. Four hundred and forty volts were chosen for the motors so that standard 600-volt rubber-insulated wire and switches could be used. Unless the conduit can be encased in concrete for the full length of the run, metal conduit should be used. Conduit fittings, rather than pipe fittings, should be used throughout. With the wires enclosed in conduit, there is no danger of workmen receiving accidental shocks through con-

tact with a wire. The wire is not pulled down and broken or otherwise disturbed by scaffolding and tackles during the overhauling period. The wiring is protected from oil and dirt and the appearance of the job is neat.

Separate conduits and circuits should be run from the main switchboard direct to distribution cabinets in the mill. Each cabinet should serve a group of motors and in order to make the wiring as short as possible, should be located approximately in the center of the group. This distribution cabinet may be an elaborate slate panel with a fused knife switch for each motor, or it may consist of an asbestos-covered two-inch board backing with externally operated iron-clad fused safety switch mounted on it. The fused switches in the cabinet should be of sufficient size to carry the full starting current of the motor served. The fuses in the distribution cabinet are for protecting the feeder from defective wiring between the motor and cabinet and the motor during starting. For protection of the motor against overload while running, I prefer relays mounted with the starting device. Fuses, unless carefully applied, are an unending source of trouble. The renewable fuse, which has come into wide use during the last few years, can be as reliable as the non-renewable type, but can give all sorts of trouble if the renewals are not put in properly. Loose fitting connections in the fuse itself, in the fuse clips or in the switch will cause heating which is carried to the link causing the fuse to blow with currents far below the capacity of the link. Overloading of switches also causes heating which may be conducted through short connections to the fuses with the same result. Another disadvantage of the fuse is that it does not have an adjustable time characteristic. In many cases of a load with high momentary peaks, it is hard to apply a fuse so that the motor can carry the peaks and at the same time be fully protected from overload, but, a relay can be adjusted to allow overloads of short duration and at the same time protect the motor against overloads of too long duration. Furthermore, when a fuse does blow, the right size replacement is not always used, so that although the first application of fuses was correct, the fusing may be later changed leaving the motor unprotected. For these reasons, I think relays are more satisfactory.

Starting devices of the auto-transformer type should be provided with a low voltage release and be so built that they cannot be left in the starting position. Starters for wound rotor motors should have low voltage release trips on the primary switch and the primary and secondary controls should be interlocked so that the switch be closed only when the controller is in the starting position.

I believe it pays to follow the code of the Fire Insurance Underwriters and Factory Mutuals all the way through the factory both for power and lighting circuits. The lighting system of the sugar factory or any other building should be as carefully designed as any other part of the equipment. With the modern gas filled lamps and industrial reflectors, all ordinary and special lighting requirements can be economically met. Poor lighting has always been a major cause of accidents both to men and machinery in industry. It pays, therefore, to use plenty of light. There are now so many portable electric tools that can be operated from the lighting circuit that it is advisable to place receptacles all over the factory for both portable lamps and tools.

Electrical Equipment of Pump Installations

With the increasing popularity of the centrifugal pump electrical motors are becoming more popular in pumping stations. Wound rotor induction motors are the best suited for pump drives. The centrifugal pumps, for best efficiency must be operated at constant speed, and both the induction motor and the synchronous motor fulfill this condition. The induction motor is easier to start and operate than the synchronous motor and is therefore in most cases preferable. Owing to the large size of motor used, squirrel cage motors are not suitable because of the large starting current taken. In most cases 2300 volts is the best motor voltage to use. Since the pumping plant is usually at some distance from the generating plant with a transmission line intervening it is necessary to use transformers. When transformers are used, the selection of the motor voltage is governed entirely by the cost of the motor and control equipment and the efficiency of the former. Under these conditions, 2300 volts are usually the best.

The control equipment of a wound rotor pump motor should consist of a panel with voltmeter, ammeter, integrating watt-hour meter and overload relays. The oil switch should be provided with low voltage release and trip coils and should be interlocked with the secondary control. For secondary control, either the drum type or the contactor type of controller can be used. If the drum type controller is used, an auxiliary contactor or switch should be provided to short circuit the controller after the motor is brought up to speed.

In cases where power is purchased there is often a penalty for poor power factor. In this case, the use of a synchronous motor may be advisable. An irrigation pumping plant is much more desirable for synchronous motor application than any place in the mill. An irrigation pump is a very steady load and the pumping plants are usually free from dust which causes trouble in machinery having moving contacts.

The control for a synchronous motor should be as simple as possible and yet be complete. The details will depend upon method of starting and control employed by the manufacturer furnishing the motor. Personally, I favor manual rather than automatic control, although I see no reason why the latter should not be very satisfactory.

For driving sump pumps, priming pumps and other small auxiliaries, a single phase motor operating on the lighting voltage will prove satisfactory. For sump pumps, a float switch automatic control works very nicely. The other motors usually will not exceed 5 h.p. and may be controlled by iron-clad safety starting switches.

For the power wiring for the pump motor, I prefer rubber-insulated wire carried on line insulators on racks on the wall and in tunnels to conduit and cable installations. If insulators are used, one need not worry about the detonation of the cable insulation due to heat and moisture.

Electrical Equipment of Generating Plants

The type of electrical equipment for generating depends upon the type of prime mover used. There are for our purposes, three types of prime mover:

turbines, engines and waterwheels, each of which requires a special design of generator although, the electrical design of the last two are about the same. In this paper I will discuss only the alternating current generator as direct current is used but very little on plantations.

Since generator design has been so well developed and standardized, for the different purposes by the builders, there is little to be said about choice of design. When you select the prime mover the generator design is automatically chosen. The main thing to consider is that the machine selected is of good substantial design properly insulated and well ventilated. The turbo alternator is always an enclosed machine with forced ventilation. For turbines it is important that the ventilating system be so designed that all passages and ducts can be readily cleaned. All turbo generators should be equipped with temperature exploring coils connected to a temperature indicator so that the temperatures in the windings can be determined. This is of great value when it is necessary to carry an overload. The engine and waterwheel type generators are open type machines and access can be had to the windings at all times so that temperatures can be observed with an ordinary thermometer.

After the generator the next thing to be considered is the exciter. For turbo generators, I do not favor the direct connected exciter because it is very hard to build commutators and armatures to stand the excessive speed. I think that any plant that is required to operate continuously should have two exciters. My first choice of an exciter is indirection motor driven. This is simplest and most efficient. The second choice is turbine driven. The turbine requires much more attention than an indirection motor and is less efficient, but in the case of central station plant the loss of efficiency may not matter, as the exhaust from the exciter turbine may help maintain the heat balance.

Where a station is not connected to other stations a motor driven exciter cannot be used unless a second steam driven exciter is used for starting up. Even where there are other stations, a steam driven exciter is handy in case of transmission line failure. For these reasons, I favor one motor driven and one steam driven exciter in a turbine driven generating plant. Where there are more than one generator in the plant, the motor driven exciter should have sufficient capacity for all the generators that will be operated at one time. This elminates all difficulties from the parallel operation of exciters especially with the regulator.

For the engine-driven or waterwheel plant, belt-driven exciters are satisfactory; or in case the speed of the main unit is high enough, a direct connected exciter may be used. In large waterwheel plants, an exciter driven by an independent waterwheel may be used, but this would not prove economical in most of the plants found in the Islands. If a spare exciter is required in the engine or waterwheel driven plants a motor driven exciter will prove most satisfactory.

The control equipment of a motor-driven exciter should not be equipped with overload or low voltage protection. In cases of short circuit or other trouble on the outside lines or feeders, it is often found that an overload relay or low voltage trip on the exciter motor control will operate before the oil switch can operate to protect the station from the section on which trouble occurred. When this occurs, the entire load is lost.

Aside from the generator the most important piece of equipment in the station is the switchboard. The switchboard layout varies, depending on the location of the station and the arrangement of lines that it feeds, so cannot well be treated in a general way.

There is one feature that can be spoken of generally and that is, the back of the switchboard should be accessible. Probably the best arrangement is to locate the oil switches and bus bars immediately below the floor upon which the switchboard stands. The generator field rheostats should be mounted above or below the switchboard level. This leaves the back of the board clear and accessible for inspection and work, and there are no dangerous potentials near the board. If it is not practicable to mount the switches below the board, the bus bars and switches should be mounted far enough back of the board so that there is at least six feet between the bus and switch structure and the back of the board. All instrument and control wiring should be run from the bus structure to the switchboard in conduit.

Transmission Systems and Methods of Distribution

The selection of transmission system equipment is largely a question of the purposes to be served. Transmission line design is too large a question to be treated here. To my mind the mechanical design of a transmission is just as important as the choice of electrical equipment. Transmission line equipment consists of four parts from the electrical viewpoint, the line itself consisting of the conductors insulated from the ground, transforming equipment, control equipment and protective equipment. The type, quantity and size of this equipment depends entirely upon the design of the line. Beyond stating that I think that the transmission line is just as important and worthy of careful study as any other portion of the electrical system, I will make no attempt at covering the subject, but leave it for some other report.

The electrical distribution system, except for that in the sugar factory which I have considered above, is always a special problem and cannot be treated briefly in a report of this scope. There are many other phases of the subject of choosing electrical equipment that cannot be gone into but it is hoped that the above covers to some extent the most general features of the subject.

Report on Soils and Fertilizers*

By Guy R. Stewart

The major portion of the work upon the problems of sugar cane soils and fertilization, carried on in Hawaii during the past year, has been done at the Experiment Station, H. S. P. A. The chemical staff of Ewa Plantation, how-

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* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

ever, has made a considerable beginning upon a study of the composition of the soils of their fields. This work is intended to supplement the analyses previously made for this plantation by the Experiment Station. The determinations made by the Ewa chemists have so far covered the amounts of strong acid soluble or reserve plant food in a large group of samples. During the present season these figures will be supplemented by the determination of the citrate soluble or available constituents in these same soils. As Ewa Plantation has an extensive group of field experiments which are to be carried on indefinitely, it is an excellent plan to obtain all possible information as to the composition of the experimental fields.

The work carried on at the Experiment Station, H. S. P. A., has been divided again, between work on the soils of the individual plantations, and extended studies of the general problem of the maintenance of fertility in the Island fields. We are steadily gaining information as to the deductions which can be drawn from analyses of plantation soils, by the relationship of our determinations to the yields obtained from field trials. Our major line of investigation of the more general problems of soil fertility, has been the study of the soil conditions underlying the occurrence of root rot or Lahaina disease. This question is still far from being completely solved, but we are obtaining a greater insight into the causes of this trouble than we have ever had before.

Work Upon Plantation Soils

Oahu Sugar Company: A survey of the content of available phosphates in part of the fields of this plantation was made in 1919. The samples were collected largely from the upper fields. A considerable deficiency of available phosphates was found in much of this mauka land. The results of these analyses were in agreement with the plot experiments carried out in Field 45, where a notable response was obtained from phosphate fertilization.

Further interest, in the composition of the Oahu soils, was aroused during the past year by the behavior of H 109 cane in Field 20. A number of poor spots appeared in portions of this field where the cane seemed to be affected by root rot. Soil samples were collected from these poor spots and from adjoining land where good cane was growing. The majority of the samples from both the good and poor areas were low in available phosphates and contained a minimum quantity of available potash. The total potash supply was excellent, but the total phosphates were distinctly low for Island soils.

A definite connection has been shown recently in the Eastern United States, between deficiencies of available phophates and potash and the occurrence of root rot in corn crops. This trouble has been found, usually, on very acid soils where toxic salts of soluble aluminum and iron are present. Such soils are found in these Islands in the mauka lands of the unirrigated plantations. At the same time there is considerable indication that plant food deficiencies may contribute to root troubles in soils that are not notably acid. It seemed desirable, therefore, to make a more general survey of the Oahu Sugar Company lands.

The results of this work showed that most of the areas which were low in available plant food were located in the mauka fields, but that Field 20 was

largely low in phosphate content. Further field experiments with phosphates and potash were recommended. It was concluded that the appearance of root rot in Field 20 was due to a deficiency of plant food and a poor water-holding capacity in the soil of limited areas. The affected cane was given additional fertilization and extra irrigation and has now recovered completely.

Waialua Agricultural Company: A group of samples were analyzed from the various sections of this plantation. A wide range of variation is found in the physical texture and characteristics of the soils found in the Waialua fields. In general, the soils of the lower land were well supplied with both potash and phosphates, while certain of the upper areas were notably low in phosphates. Field experiments were suggested for various sections to develop more exact information as to fertilizer requirements.

Hawaiian Sugar Company: There are a number of ridges and valleys separating the fields, but the soils found in the different sections are rather similar in physical texture. In general, they are reddish, silty, clay loams of good depth, underlain by more compact subsoils at about three feet down.

The analyses of samples from typical areas, appeared to justify the following deductions: A considerable degree of variability was found to exist in the samples from the same fields and from adjoining areas of similar physical appearance. Approximately one third of the samples were found to be low in available phosphates, and almost one half were slightly low in available potash. These results would indicate the desirability of continuing the present applications of phosphoric acid to all the fields. The number of samples containing a minimum quantity of potash would make it desirable to either install potash tests or to add potash to the mixed fertilizers as crop insurance.

Niulii Mill and Plantation: A collection of representative samples from Niulii Plantation were analyzed during the past year. The results showed that about a quarter of the samples were low in available phosphates and about three fourths of the samples were low in available potash. This indicated that most of the plantation cane land was probably giving little return from phosphate applications, but on account of the low areas it was wise to continue moderate phosphate applications. The potash figures indicated a fairly general need of moderate potash applications. These conclusions agree with the results obtained from the field experiments conducted by the Agricultural department.

Hutchinson Sugar Plantation Company: The fields of this plantation were sampled in December, 1923. At this time there was about 3,600 acres in cane. The Manager, Mr. William Campsie, hoped to increase this area to 4,000 or 4,400 acres. In considering this possible expansion, he was anxious to obtain information as to soil and subsoil differences in the various portions of the plantation. The lower fields above Naalehu, and those near Honuapo and Hilea, have been giving excellent yields. Another group of fields in the central section above Naalehu had good crops started upon them, but had been rather uncertain in past production. The very highest fields above Naalehu had been largely out of cultivation for some time.

In general, all the lower fields were found to be well supplied with available plant food. Certain of the central and upper fields above Naalehu were found

to be rather weak in available plant food, but these soils were free from toxic acidity in both the surface and subsoil. Experimental applications of reverted phosphate were recommended for this upper land and deep plowing, on a small scale, was also suggested.

Investigations of the General Properties of Hawaiian Soils

Root Rot Investigations

During the past year our principal investigational problem has been a study of the factors underlying the occurrence of root rot or Lahaina disease. During this time Mr. McGeorge has devoted his entire time to the problem and other members of the Chemistry department have also worked upon the investigation. I think our work has progressed to a point where I am justified in stating that there is every indication that a variety of causes underlay the occurrence of Lahaina disease.

There now seems to be strong evidence that unfavorable soil conditions have been among the determining factors in causing cane to fail through the roots rotting off. In some instances high acidity and consequent toxic quantities of aluminum and iron salts appear to have been among the causative factors. In still other cases seasonal accumulations of salts from irrigating water or an unfavorable alkalinity of the soil, would account for the trouble. It still remains to be shown what the relation of root failure or root rot is to the attacks of soil fungi or soil bacteria; and whether the root injuries caused by snails, centipedes or similar soil inhabitants are a determining factor in such troubles.

The first work undertaken by us was to try and find whether toxic concentrations of aluminum and iron salts would explain the occurrence of root rot here in Hawaii. This work was carried out both in solution and in soil cultures. Great difficulty was experienced in growing cane in solution and sand cultures on account of fermentation and spoilage of the seed piece. Mr. McGeorge finally developed a method by which he obviated this difficulty through the use of the shoots which develop from seed cane. This work has been published in the *Record* for July, 1924, so I shall not give further details of the technique. The general result of these investigations has been to show that salts of aluminum are toxic to cane. These salts were only found in solution in the more acid soils, that is, those with a reaction below pH 5.8. Soils from the upper Hamakua coast and windward Oahu were used in pot cultures and the toxic aluminum was found to be the cause of root failure. This root failure was prevented, in the pot tests, by heavy applications of superphosphate or by partial neutralization of the soil with lime and the use of moderate amounts of superphosphate. Field tests have now been installed at Honokaa, Olaa and Grove Farm to try out these methods of treatment on acid soils under field conditions.

Later work was undertaken to try and find the cause of the failure of Lahaina upon the neutral soils of the irrigated plantations. One of the causes of such failure appears to be seasonal accumulations of salts from the irrigating water. This work has been discussed in detail in the *Record* for July, 1924. Another cause of root failure was found by work at Oahu Sugar Company to be a

deficiency of available plant food. In this instance it was available phosphates. Still another instance of root failure was investigated in central Maui at the Hawaiian Commercial and Sugar Company. An unfavorable degree of alkalinity was found in the preliminary work, but further study is still to be carried out in this district.

During the present summer Mr. McGeorge has visited the prominent investigators of root rot problems in the Eastern United States and has become thoroughly conversant with the work which they have under way. He conferred with the investigators at Indiana, New Jersey, Rhode Island, Wisconsin and the U. S. Department of Agriculture at Washington, D. C.

Preliminary Work on Pahala Blight

During the past winter there was considerable Pahala blight in certain fields of the Hawaiian Agricultural Company. Mr. McGeorge visited Pahala in January of this year, took soil samples of typical blight and non-blighted fields and also collected samples of blighted and normal leaves. Besides collecting the above samples, he obtained some large lots of soil and later displaced the soil solutions and used these solutions for the growth of cane shoots.

Analyses of the soils indicated that the blight soils had a more shallow surface soil with a marked decrease of available plant food in the subsoils. The analyses of the cane leaves showed that the blight-free leaves had a higher ash and silica content than those affected by blight. An increased absorption of silica is generally affected by a satisfactory content of available phosphates, so this also points to a lack of available plant food as one of the causes of the trouble.

The growth of cane shoots in soil solutions from the blight and non-blight soils showed a notably better growth in the solutions from the blight-free soils. The analyses of the solutions did not show a consistent difference which would account for this difference in growth.

We have since made a fairly complete soil survey of the fields of Hawaiian Agricultural Company to find if there are consistent differences in the soils of all the blight and blight-free fields. Work is now under way upon these samples. This will be followed by further work on the composition of the cane when blight is present and a continuation of the cultural experiments.

Sugar Prices

96° Centrifugals for the Period

Dec. 17, 1924, to March 11, 1925

Date	Per Pound	Per Ton	Remarks
Dec. 17, 1924.....	4.77¢	$95.40	Cubas.
" 22..........	4.74	94.80	Cubas, 4.77, 4.71.
" 23..........	4.71	94.20	Cubas, 4.77, 4.65; Philippines, 4.71.
" 26..........	4.65	93.00	Cubas.
" 27..........	4.59	91.80	Cubas.
Jan. 2, 1925.....	4.65	93.00	Cubas.
" 6..........	4.59	91.80	Cubas.
" 8..........	4.55	91.00	Porto Ricos.
" 9..........	4.535	90.70	Cubas, 4.55, 4.52.
" 10..........	4.59	91.80	Cubas.
" 13..........	4.535	90.70	Cubas, 4.55; Porto Ricos, 4.52.
" 14..........	4.55	91.00	Porto Ricos.
" 16..........	4.57	91.40	Cubas, 4.55, 4.59.
" 17..........	4.59	91.80	Cubas.
" 19..........	4.62	92.40	Cubas, 4.62, 4.65; Porto Ricos, 4.59.
" 20..........	4.65	93.00	Cubas.
" 21..........	4.62	92.40	Cubas, 4.65; Porto Ricos, 4.59.
" 22..........	4.59	91.80	Cubas.
" 23..........	4.535	90.70	Cubas, 4.52, 4.55.
" 24..........	4.52	90.40	Porto Ricos.
" 26..........	4.59	91.80	Cubas.
" 29..........	4.65	93.00	Cubas.
" 30..........	4.635	92.70	Cubas, 4.65, 4.62.
" 31..........	4.635	92.70	Cubas.
Feb. 2..........	4.65	93.00	Cubas.
" 4..........	4.59	91.80	Cubas.
" 9..........	4.62	92.40	Porto Ricos, 4.59; Cubas, 4.65.
" 11..........	4.59	91.80	Cubas.
" 17..........	4.62	92.40	Cubas.
" 18..........	4.605	92.10	Cubas, 4.62; Porto Ricos, 4.59.
" 19..........	4.59	91.80	Cubas.
" 25..........	4.65	93.00	Cubas.
" 26..........	4.725	94.50	Cubas, 4.71; Porto Ricos, 4.74.
" 27..........	4.755	95.10	Cubas, 4.77, 4.74.
" 28..........	4.74	94.80	Cubas.
Mar. 3..........	4.725	94.50	Cubas, 4.74, 4.71.
" 4..........	4.71	94.20	Cubas.
" 5..........	4.74	94.80	Cubas.
" 6..........	4.755	95.10	Cubas, 4.74, 4.77.
" 7..........	4.84	96.80	Cubas.
" 9..........	4.825	96.50	Cubas, 4.84; Porto Ricos, 4.81.
" 10..........	4.79	95.80	Cubas, 4.81, 4.77.
" 11..........	4.77	95.40	Cubas.

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D 1135 in the Argentine

In a recent report of the Argentine Sugar Experiment Station, by Dr. William C. Cross, Director, several statements are made which are of interest to us here in Hawaii.

Referring to D 1135 he has this to say:*

The experiments with this variety have been continued in five different plots. The last two years' results have been in general quite good, although it is proven that this cane is not as good as the P. O. J. 36 and 213. Although in the beginning it showed considerable resistance to mosaic disease, in the last two years it has been more attacked by the pest than the Java canes. In conclusion we may say that this variety has not turned out to be as valuable as it promised to be at first and cannot be recommended in preference to the Java varieties generally planted.

The Java canes which he mentions, P. O. J. 36 and 213, have now been distributed to all plantations here which desired to try them out, and we are in a splendid position to spread them rapidly should they prove to be superior to D 1135 here.

In connection with two other Java canes which we have here, now growing in quarantine, P. O. J. 2714 and 2725, Dr. Cross has the following to say:

P. O. J. 2714: This is another variety which is considered immune (or almost immune) to the mosaic disease in Java, where it is cultivated to a total extension of some 70,000 acres. In that country it is a cane of excellent yields of cane and sugar per hectare, having also a fairly high fiber content (average 12.5 per cent). Its stalks are thick and heavy, yellowish brown in color. Here we have had it under experimentation only a short time and on a small scale as yet, but it appears to promise well. One analysis of the plant cane made very early in the grinding season (May 17, 1923) gave the following results: Brix, 12.97 per cent; sucrose, 9.03; purity, 69.62. We have no tonnage results as yet, but its appearance in the field is promising.

P. O. J. 2725: This variety is also considered immune, or almost immune, to the mosaic disease in Java, where many of the factories cultivate it in a small way, the total extension in 1922 being over five thousand acres. It is a green cane of thick stalk, very vigorous in growth and of satisfactory sugar content. Of all these varieties which are immune, or almost immune, to the mosaic disease it is the one which up to now promises to give the best results in this country. We have three plots of this variety. One on a small scale, established in 1920 (plot C); another planted in 1921 (plot A), and the third in 1922 (plot B).

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* From *Facts About Sugar*, May 23, 1925, p. 499.

In view of its good production of cane and sugar per acre, its great resistance to the mosaic disease, and its general properties of being a thick, heavy cane, easy to strip and cheap to transport to the mill, we consider that this cane is one of the most promising of the new varieties which this institution possesses. We have already established with this cane a number of cooperative experiments in the lands belonging to the factories in various parts of the country, and up to now the opinion of everyone respecting this variety is quite favorable.

[J. A. V.]

Present Fertilizer Practices on the Sugar Plantations of the Hawaiian Islands*

By J. A. Verret

First of all the committee desires to thank the plantations for their splendid cooperation in this work. Thirty-eight replies to the questionnaires sent out were received. All the plantations on Oahu and Maui replied, and all but two on Hawaii. Kauai made the poorest showing with no replies from three.

Mixed Fertilizers

From the replies received we find that 19 different formulas are used on 34 plantations. Four of the plantations reporting do not use ready mixed fertilizers. Of these four, two use nitrogen only, another of them uses superphosphate in addition to nitrogen on the upper fields, while a fourth uses bonemeal and potash from molasses ash, in addition to nitrogen as field tests show their need on different fields.

The different formulas used, their approximate make-up, the pounds of filler and the number of plantations using them are listed below:

No.	Formula		Pounds per Ton	No. of Plantations Using
1.	12% N.......	5% Ammo. Sulph. 6% Nit. Potash 1% Organic	488 lbs. Ammo. Sulph. 857 lbs. Nit. Potash 210 lbs. Superphos. 273 lbs. Bone meal	5
	5% P_2O_5.....	2% Superphos. 3% Bone meal	160 lbs. Sulph. or Muriate Potash 12 lbs. filler	
	10% K_2O....	6% Nit. Potash 4% Sulph. or Muriate Potash		
2.	12% N.......	5½% Ammo. Sulph. 6% Nit. Potash ½% Organic	537 lbs. Ammo. Sulph. 857 lbs. Nit. Potash 273 lbs. Bone meal 160 lbs. Sulph. Potash	1

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

3% P_2O_5.....	Bone meal	173 lbs. filler	
10% K_2O....	4% Sulph. Potash		
	6% Nit. Potash		

3.

11% N.......	10% Nit. Soda	1,200 lbs. Nit. Soda	1
	1% Organic	273 lbs. Bone meal	
		360 lbs. Sulph. or Muriate Potash	
3% P_2O_5.....	Bone meal	77 lbs. filler	
9% K_2O.....	Sulphate or Muriate?		

3A. Another same as above except no phosphoric acid.

4.

11% N.......	4½% Ammo. Sulph.	439 lbs. Ammo. Sulph.	1
	6% Nit. Potash	857 lbs. Nit. Potash	
	½% Organic	158 lbs. Superphos.	
		136 lbs. Bone meal	
3% P_2O_5.....	1½% Superphos.	40 lbs. Sulph. Potash	
	1½% Bone meal	370 lbs. filler	
7% K_2O.....	Pot. Nit. and Sulph.		

5.

11% N.......	6% Nit. Potash	857 lbs. Nit. Potash	6
	4% Ammo. Sulph.	390 lbs. Ammo. Sulph.	
	1% Organic	316 lbs. Superphos.	
		273 lbs. Bone meal	
6% P_2O_5.....	3% Superphos.		
	3% Bone meal	167 lbs. filler	
6% K_2O.....	Pot. Nitrate		

6.

11% N.......	4½% Ammo. Sulph.	439 lbs. Ammo. Sulph.	1
	6% Nit. Potash	857 lbs. Nit. Potash	
	½% Organic	316 lbs. Superphos.	
		273 lbs. Bone meal	
6% P_2O_5.....	3% Superphos.	115 lbs. filler	
	3% Bone meal		
6% K_2O.....	Potash Nit.		

7.

12% N......	5½% Nit. Potash	786 lbs. Nit. Potash	1
	6% Ammo. Sulph.	585 lbs. Ammo. Sulph.	
	½% Organic	316 lbs. Superphos.	
		273 lbs. Bone meal	
6% P_2O_5.....	3% Superphos.	40 lbs. filler	
	3% Bone meal		
5% K_2O.....	Nit. Potash		

8.

11% N......	5% Nit. Soda	645 lbs. Nit. Soda	3
	5½% Ammo. Sulph.	537 lbs. Ammo. Sulph.	
	½% Organic	316 lbs. Superphos.	
		273 lbs. Bone meal	
6% P_2O_5.....	3% Superphos.	200 lbs. Sulph. or Muriate Potash	
	3% Bone meal	29 lbs. filler	
5% K_2O.....	Sulph. or Muriate		

9.

9% N........	4% Ammo. Sulph.	571 lbs. Nit. Potash	1
	4% Nit. Potash	390 lbs. Ammo. Sulph.	
	1% Organic	316 lbs. Superphos.	
		273 lbs. Bone meal	

	$6\%\ P_2O_5$.....	3% Superphos. / 3% Bone meal	83 lbs. Sulph. Pot.	
			367 lbs. filler	
	$6\%\ K_2O$......	Nitrate and Sulph.		
10.	$10\frac{1}{2}\%$ N.....	5% Nit. Soda	645 lbs. Nit. Soda	1
		5% Ammo. Sulph.	488 lbs. Ammo. Sulph.	
		$\frac{1}{2}\%$ Organic	83 lbs. Dried blood	
			579 lbs. Superphos.	
	$6\%\ P_2O_5$.....	$5\frac{1}{2}\%$ Superphos. / $\frac{1}{2}\%$ Bone meal	120 lbs. Sulph. of Potash	
			46 lbs. Bone meal	
	$3\%\ K_2O$.....	Sulphate	39 lbs. filler	
11.	9% N.......	$2\frac{1}{2}\%$ Nit. Potash or Soda	357 lbs. Nit. Potash	1
		6% Ammo. Sulph.	585 lbs. Ammo. Sulph.	
		$\frac{1}{2}\%$ Organic	474 lbs. Superphos.	
			409 lbs. Bone meal	
	$9\%\ P_2O_5$.....	$4\frac{1}{2}\%$ Superphos. / $4\frac{1}{2}\%$ Bone meal	140 lbs. Sulph. Potash	
			35 lbs. filler	
	$6\%\ K_2O$.....	Nitrate or Sulph.		
12.	9% N.......	$2\frac{1}{2}\%$ Ammo. Sulph.	244 lbs. Ammo. Sulph.	1
		6% Nit. Potash	857 lbs. Nit. Potash	
		$\frac{1}{2}\%$ Organic	526 lbs. Superphos.	
			273 lbs. Bone meal	
	$8\%\ P_2O_5$.....	5% Superphos. / 3% Bone meal	100 lbs. filler	
	$6\%\ K_2O$.....	Nit. Potash		
13.	9% N.......	3% Nit. Soda	387 lbs. Nit. Soda	1
		3% Ammo. Sulph.	293 lbs. Ammo. Sulph.	
		3% Organic	333 lbs. Dried blood	
			636 lbs. Bone meal	
	$7\%\ P_2O_5$.....	Bone meal	280 lbs. Sulphate Potash	
			71 lbs. filler	
	$7\%\ K_2O$.....	Sulphate		
14.	8% N........	5.33% Ammo. Sulph.	522 lbs. Ammo. Sulph.	1
		2.67% Pot. Nit.	379 lbs. Pot. Nit.	
			739 lbs. Superphos.	
	$7\%\ P_2O_5$.....	Superphos. ?	173 lbs. Sulph. Potash	
			146 lbs. filler	
	$7\%\ K_2O$.....	Nit. and Sulph.		
15.	7% N........	2% Ammo. Sulph.	195 lbs. Ammo. Sulph.	2
		2% Nit. Potash	286 lbs. Pot. Nit.	
		3% Organic	417 lbs. Dried blood (?)	
			368 lbs. Superphos.	
	$7\%\ P_2O_5$.....	$3\frac{1}{2}\%$ Superphos. / $3\frac{1}{2}\%$ Bone meal	160 lbs. Sulph. or Muriate Potash	
			318 lbs. Bone meal	
			256 lbs. filler	
	$6\%\ K_2O$.....	2% Nit. Pot. / 4% Sulph. Pot.		
16.	7% N.......	$3\frac{1}{4}\%$ Nit. Soda	419 lbs. Nit. Soda	1
		$3\frac{1}{4}\%$ Ammo. Sulph.	317 lbs. Ammo. Sulph.	
		$\frac{1}{2}\%$ Organic	789 lbs. Superphos.	
			227 lbs. Bone meal	

	$10\% \ P_2O_5$....	7½% Superphos.	160 lbs. Sulph. or Muriate Potash	
		2½% Bone meal	88 lbs. filler	
	$4\% \ K_2O$.....	Muriate or Sulph.		
17.				
	$11\frac{1}{4}\%$ N....	5¾% Nit. Soda	742 lbs. Nit. Soda	1
		5% Ammo. Sulph.	488 lbs. Ammo. Sulph.	
		½% Organic	395 lbs. Superphos.	
			273 lbs. Bone meal	
	$6\frac{3}{4}\% \ P_2O_5$...	3¾% Superphos.	102 lbs. filler	
		3% Bone meal		
18.				
	8% N........	2⅔% Nit. Soda	342 lbs. Nit. Soda	1
		5⅓% Ammo. Sulph.	522 lbs. Ammo. Sulph.	
			632 lbs. Superphos.	
	$7\% \ P_2O_5$.....	6% Water Soluble	91 lbs. Bone meal	
		1% Bone meal	413 lbs. filler	
19.				
	8% N.......	4% Nitrate	516 lbs. Nit. Soda	4
		4% Sulphate	390 lbs. Ammo. Sulph.	
			842 lbs. Superphos.	
	$10\% \ P_2O_5$....	8% Water soluble	182 lbs. Bone meal	
		2% Bone meal	70 lbs. filler	

Formulas 1 to 4 inclusive are used in districts where tests have shown a potash shortage but practically no response to phosphoric acid.

We believe that these formulas serve the purpose very well. Nos. 1, 2 and 3 are very concentrated, carrying little filler. No. 4 is not quite so good, carrying as it does 370 pounds of filler or inert matter. For every ton of it used, freight must be paid on 370 pounds of useless material, as well as packing it up steep trails. We believe a saving on freight and handling could be made by adding 1 per cent to each ingredient, making the formula 12-4-8 and using, say, 10 to 15 per cent less of it.

Nos. 5, 6, 7, 8 and 13 are all very good for conditions where a general fertilizer is wanted, that is, where the need for neither phosphoric acid or potash predominates. We prefer 5, 6, 7 or 8 to 13. The 3 per cent organic nitrogen in 13 makes it more expensive, while our tests show organic nitrogen to be less efficient than the soluble forms.

No. 9 has entirely too much filler, 367 pounds. Either 5, 6, 7 or 8 could be substituted to advantage, the amounts applied being cut down to correspond to the increased nitrogen.

No. 10 is good where the soil shows some need for phosphoric acid while the potash requirements are not especially manifest.

Nos. 11 and 12 are good formulas. They are used on places where phosphoric acid especially, in addition to nitrogen, is wanted.

No. 14 has 146 pounds of filler; this is too much. The nitrogen could be increased with a corresponding decrease in the amount of fertilizer used.

No. 15. We believe better results could be obtained if this formula were changed for No. 5, for instance. Cane is a heavy nitrogen feeder and, for best results, we like to see nitrogen predominate in our mixtures, and 3 per cent organic nitrogen makes it more expensive.

No. 17 is a good mixture where potash is not wanted.

TABLE I

Plantation	Formula	Pounds of Mixed Fertilizer	Number of Applications	Second Season Material Used	Second Season Number of Applications	Total Pounds per Acre N	P_2O_5	K_2O
Waiakea Mill Co.	2	1250 to plant	Plant 2	N. of S.	1	150–210	23–53	75–175
		750 to 1750 to ratoons	Ratoons 1 or 2	320 to 500				
Olaa Sugar Co., Ltd	3, 3A	1750 for 1st and 2nd season			4 altogether	193	0–53	158
Hilo Sugar Co.	1	500, M. F., 1000 P. N.	3	500 P. N.	1	210	25	150
Onomea Sugar Co.	1	1500 to 1800	3	500–600 P. N.	1	255–291	75–90	200–240
Pepeekeo Sugar Co.	1	500 to 1000 (?)	2	250–500 P. N.		....	.....	....
Honomu Sugar Co.	1	1125	2	425 P. N.	1	195	56	155
			Mauka lands 3					
Hakalau Plantation Co.	1	1200–1500	Plant 3	300–400 N. S.	1	190	60–75	120–150
			Ratoons 2					
Laupahoehoe Sugar Co.	8	1000–1200	3–4	375–625 N. S.	1–2	168–229	60–72	50–60
Kaiwiki Sugar Co., Ltd	8	1250	2	250 N. S.	1	176	75	63
Hamakua Mill Co.	4	1000	2	250 N. S.	1	149	30	70
Paauhau Sugar Plantation Co.		250 bone meal,	2–4	300–600 N. S.	1–2	149–196	58	0–150
		600 N. of S.						
		0 to 150 lbs. K_2O from molasses ash						
Kaeleku Plantation Co., Ltd.	5	1000	1–2	300–600 N. S.		156–203	60	60
Niulii Mill & Plantation	5	1000	3	250–300 N. S.	1	150–156	60	60
Union Mill Company	7	500 to 750	1	250–500 N. S.	1	100–170	30	25
Kohala Sugar Company	13	1250	2	250–300 N. S.	1	152–160	88	88
Halawa Plantation, Ltd	8	800–1000	2	250–300 N. S.	1	127–156	48–60	40–50
Hawi Mill & Plantation Co., Ltd.		1000–1250 lbs. N. of S.	N. of S. used throughout		2	155–194		
Hutchinson Sugar Plantation Co.	5	1000–1500	3	250 N. S.	1	150–204	60–90	60–90
Hawaiian Agricultural Co.	5	1200–1700	3	225–300	1	167–233	72–102	72–102
Maui Agricultural Co., Ltd.	19	625	1	550 N. S.	2	167	63	
				150 Am. Sulph.				
Olowalu Company	5	1000 plant and long rat.	2	400–650 N. S.	1	170–210	60	60
		750 short ratoon	1			143–183	45	45
Wailuku Sugar Co.	6	1000 plant	2	500 N. S. plant	1	204	60	60
		1000 ratoons	1	400 N. S. ratoon	1	173	60	60
		1000 N. S. short ratoon	1			156		
Hawaiian Commercial & Sug. Co.	19	625	1	750 N. S. ratoons	2–3	167	63	
		625	1	850 N. S. plant	2–3	182	63	
Pioneer Mill Co., Ltd.		437½ Superphos. upper lands	Plant 2					
		437½ Am. Sulph.	Ratoons 1	567½ N. S.	1	175	0–87	
Waianae Company		60 lbs. N. from N. of L.	3	90 lbs. N. from N. of L.	2	150		
Waimanalo Sugar Co.	6	875 plant and long ratoon	1	625 N. S.	1	194	53	53
		625 short rat. 250 lbs. N. S.	2			108	37	37
Kahuku Plantation Co.	19	750 plant	1	800–1000 N. S.	1	184–215	75	75
		750 long ratoon	1	600–1000 N. S.	1	153–215	75	75
		375 short rat. 300–400 lbs. N. S.	2			76–92	38	38
Ewa Plantation Co.		175–275 lbs. N.	1–2	75–150 N. *	1–2	175–275	0–200	
Honolulu Plantation Co.	15	900–1000	2	625 N. of S.	1	160–167	63–70	54–60
Oahu Sugar Co., Ltd.	11	1000	1	625–875 N. of S.	2	187–225	90	60
Waialua Agricultural Co., Ltd.	14	1000	1	500–600 N. S.	1	158–173	70	70
Kekaha Sugar Co., Ltd.	16	750–1000	1	800–1000 N. S.	3	196–244	75–100	30–40
		125 N. S.						
The Waimea Sugar Mill Co.	16	1000	1	1000 N. S.	3–4	225	100	40
Hawaiian Sugar Co.	18	1000	1–2	300–400 N. S.	1–4	126–142	70	
The Koloa Sugar Co.	12	1000	1	250–1000 N. S.	1–2	129–245	80	60
The Lihue Plantation Co., Ltd.	17	600–1000 plant in makai fields				192–236	41–67	
			1	800 N. S. makai	2	107–162	27–41	
		400–600 plant in mauka fields		400–600 N. S. mauka				
		400–600 long and short ratoon						
McBryde Sugar Co., Ltd.	19	625	1	250 lbs. mixture (½ Nit., ½ Sul.)	2	150–225	63	
				500–700 lbs. Nit. Soda				
Kilauea Sugar Plantation Co.	5	800	Plant 1					
			Ratoons 2	375–500 Nit. Soda or Nit. L.	1	146–164	48	48

* Included in totals given for first season.

No. 18 carried 413 pounds of filler, which is a waste. We would favor increasing the nitrogen and adding some potash to this.

Nos. 16 and 19. At first sight, we do not like these mixtures. We know of no reason, and have access to no data in the Islands which indicate that phosphoric acid should predominate in a mixed fertilizer. Sugar cane uses less phosphoric acid than it does of either nitrogen or potash. A ton of cane uses approximately 3 to 4 pounds of nitrogen, 1.5 pounds of phosphoric acid and 2.7 pounds of potash. Our soils, except for some upper areas, are fairly well supplied with phosphoric aid. But when one inquires as to how these mixtures are used the objection to them tends to largely disappear. This mixture is used for the first application only and the phosphoric acid is made high in order that all of it may be applied in one dose to the young cane. This is the correct procedure because the main function of phosphoric acid is to promote root growth, so the only final objection that we have to this mixture is that it contains no potash.

Summary

First: For districts of potash shortage and no special need for phosphoric acid we believe formulas 1 and 2 to be the best.

Second: For districts where phosphoric acid is lacking and the need for potash not so great we suggest No. 11.

Third: For general conditions where neither phosphoric acid or potash are particularly lacking, Nos. 5, 6, 7 or 8 serve the purpose very well. They are practically identical. It will be noted that these formulas are all for concentrated mixtures. This saves bags, freight and handling. In order to put up these mixtures the use of potash nitrate is sometimes necessary. If for any reason potash nitrate becomes unavailable these formulas will need to be changed.

Total Amounts of Fertilizer Used

We tabulate herewith, in Table I, the total amounts of both mixed fertilizer and nitrogen dressing used by the different plantations; also number of doses in which it is applied and the total nitrogen, phosphoric acid and potash which this involves.

A study of this list shows that nitrogen is used in amounts ranging from about 100 pounds to approximately 300 pounds per acre. These extremes are not abnormal. Fields producing 90 to 100 or more tons of cane per acre need 300 or more pounds of nitrogen if they are to keep their fertility. On the other hand, some other field which, on account of altitude, lack of water, disease, or unsuited variety, produces but 30 tons, does not need more than 100 pounds of nitrogen per acre. The point here is that if some other factor is keeping down the yield to a certain level, increasing the fertilizer used will not raise the yield above this level, until the disturbing factor is eliminated.

We note that quite a large number of the managers report a uniform application of fertilizer to all fields. We believe this to be wrong. Fertilizing cannot be made into a standard routine if the best results are to be obtained. No plantation has uniform fields or uniform conditions, and in order to obtain the best results each field should be studied by itself and fertilizer used accordingly.

This point is well stated in the reply of one plantation to question 3: "Please state briefly your policy in regard to the amounts used in various fields." We have heard a great deal recently about the enormous yields obtained at Ewa. Here is their answer to question 3: "No set rule; varies with (a) time of starting field, (b) time of harvesting, (c) soil conditions, (d) stand of cane, (e) drainage conditions, (f) weed condition of field."

We strongly urge upon all those having to do with the fertilization of our sugar cane to carefully consider these points.

We note that most of our fertilizer is applied in from 2 to 3 doses, sometimes 4, depending on the length of crop. We do not believe it is necessary to apply fertilizer in more than 4 doses; on the other hand, unless the crop is to be only 12 months or so, it may not be wise to have less than 2 doses.

Age of Cane When Fertilized—Practice in Regard to Weeds

We give herewith, in Table II, a list of the plantations showing at what age the first dose of fertilizer is applied, how long before harvest is the last fertilization on and what the practice is in regard to weeding before fertilization.

The list is self-explanatory and requires no extended comment. The first fertilizer is applied when the cane is from about one to six months old, and the last applied six to eighteen months before harvest.

We believe everyone realizes the importance of an early start of the young cane and that the apparent delay in fertilization in some cases is due to unavoidable circumstances. For instance, there is no use to fertilize a field unless you have labor to irrigate and weed it as well. In other words, the practice may be one of compulsion and not choice. But every effort should be made not to unduly delay fertilizing the young cane. Early fertilization not only gives one more growing time, but by hastening the closing in of the cane weeds are suppressed, which, in turn, helps in the control of mosaic.

The opinion is general that fields should be clean when fertilized. But the "intensity" of the opinion varies to some extent. Some managers say they do not fertilize until the fields are clean, no matter how much that delays fertilization. Others prefer to go ahead with the fertilizer rather than be unduly delayed. That is a question for serious consideration. Both sides have good arguments. However, we are inclined to take the middle of the road in this as being probably better than either extreme. Of course, we all know that fertilizer should be applied to clean fields and that we should exert every effort to do so. But, sometimes after "exerting every effort" the fields are still not clean, then what are you going to do? Let it go without fertilizer, or, if the cane is big enough, give a big application of fertilizer to force the cane above the weeds?

Winter Fertilization

Opinion in regard to winter fertilization is fairly well divided, twenty-one managers report in favor and seventeen against.

Mr. Larsen, of Kilauea, says: "No. It is very dangerous with us, since we get no response in a cold and wet winter."

TABLE II

Plantation	Age of Cane at First Fertilization	Do You Weed Before Fertilizing?	How Long Before Harvest is Last Fertilization?
Hilo Sugar Company	2 to 4 months	Must be clean	Not less than 12 months
Onomea Sugar Company	1 foot high; 2nd, 3 months later	Yes—or immediately after	10 to 12 months or more
Pepeekeo Sugar Company	No fixed rule	Yes—or immediately after	12 months
Honomu Sugar Company	After first hoeing	Always weed	8 to 10 months
Hakalau Plantation Company	After first hoeing	Clean if possible without too much delay	Finish by May
Laupahoehoe Sugar Co	4 to 6 weeks	Weed before fertilizing	5 to 6 months
Kaiwiki Sugar Co., Ltd	4 months	Weed before fertilizing	12 months
Hamakua Mill Company	2 months	Weed before fertilizing	12 months
Paauhau Sugar Plantation Co	1 month	Weed before fertilizing	12 months
Niulii Mill & Plantation	2 months	Weed first	10 to 12 months
Halawa Plantation, Ltd	3 months	Weed first	12 months
Kohala Sugar Co	3 months	Weed if necessary	Not less than 10 months
Union Mill Co	4 to 6 months	Weed first	At least one year
Hawi Mill & Plantation Co., Ltd			Not less than 10 months
Hutchinson Sugar Plantation Co	Right after offbarring	Weed first	12 months or more
Hawaiian Agricultural Co	Get all fertilizer on before cane is 12 months	Weed first	12 months or more
Olaa Sugar Co., Ltd	3-6-9-14 months	Yes—in times of labor shortage not so careful	9 months
Waiakea Mill Company	2-5 months	Always weed	9 months to one year
Pioneer Mill Co., Ltd	1½ to 2 feet high or sooner	Weed if possible	One year
Olowalu Company	1 to 2 months	Weed first	10 to 12 months
Wailuku Sugar Co	1 to 2 months	Weed first	12 to 18 months
Hawaiian Commercial & Sugar Co	4 to 5 months	Weed first	Last application in March
Maui Agricultural Co., Ltd	3 to 6 months	Generally, clean fields	9 to 12 months
Kaeleku Plantation Co., Ltd	3 to 4 months	Always weed first	8 months
Waimanalo Sugar Co	When about 1½ feet high	Weed first	At least one year
Kahuku Plantation Co	8 to 12 weeks	Weed first	Finish by June 1
Waialua Agricultural Co., Ltd	4 to 5 months	Weed first	10 to 12 months
Waianae Company	Plant 5th water, ratoon 1 or 2 water	Weed when possible	8 to 12 months
Ewa Plantation Company	Varies—no set rule	Always clean fields	Not less than 12 months
Oahu Sugar Co., Ltd	1½ to 2 months	Clean when possible	8 to 12 months
Honolulu Plantation Co	2 months	Always clean fields	9 to 18 months
Kekaha Sugar Co., Ltd	2 months	Weed first	6 months
Waimea Sugar Mill Co	1 month	Weed if possible	10 months
Hawaiian Sugar Co	3 months	Fields must be clean first	5 to 6 months
McBryde Sugar Co., Ltd	1 to 3 months	Weed if possible	10 to 12 months
Koloa Sugar Co	1½ to 2 months	Weed if possible	12 months or more
Lihue Plantation Co., Ltd	3 to 4 months	Clean	Finish by June 15
Kilauea Sugar Plantation Co	3 to 6 months	Weed first or immediately after	Not less than 9 months

Mr. Baldwin, at Kahuku, takes the other side, saying: "Yes, very beneficial at Kahuku, as it appears to assist cane to withstand the wet, cold climatic conditions of this side of the island."

Mr. Thomson, at Waialua, sees no merit in it. "I am opposed to winter fertilization, as it has a tendency to make the cane very soft and more susceptible to disease."

Mr. Penhallow, at Wailuku, explains his position as follows: "Yes, good practice for Wailuku. All fertilizer is applied before end of January, usually in December in order to get benefit of winter rains. Have better growth on cane since this has been made standard practice here."

The same argument applies in Kohala and Hamakua when the rains come in winter and the summers are generally dry.

Mud Press Cake

Only one or two plantations report not using all their mud press cake on the fields. The majority of opinion is that the best way to use it is by plowing in plant fields. "Dressing up" poor spots is a close second. It is generally applied fresh, although in many places, on account of the rush of harvesting it is piled up to the end of the season. The majority of opinions also agree that it should be covered, but this is not always done. Much of the press cake is applied in the irrigation water. When used this way much of the nitrogen and organic matter is lost, while the phosphoric acid, potash and lime are delayed in their action as they cannot become active until after they become incorporated in the soil.

The opinion of the value of a ton of press cake varies rather widely. Values ranging from \$2 to \$20 per ton are given; \$5 to \$10 is the figure most commonly given, followed rather closely by a value of from \$2 to \$5. As a whole the managers along the Hilo coast give press cake a higher value than do the managers from other districts.

One manager (not from the Hilo coast) said he had "No press cake, thank God!" so that is another value. But this manager was thinking of the mill rather than the field.

Liming

But six plantations report the use of any lime on their fields, and most of these report its use occasionally and not as a regular practice. When used it is applied at the rate of from one to four tons per acre.

The Need of Some Filler in Mixed Fertilizer Explained by the Manufacturer

In the mixing of fertilizer of a certain guarantee it is not possible, of course, to get this exactly in a commercial plant for a number of reasons, such as slight variations in the composition of the materials used, the difficulty of taking samples which absolutely represent the lot sampled, the allowable errors in analyses, etc. So, in order to be on the safe side and not have to pay a shortage rebate the manufacturer generally makes his mixture slightly above guarantee. In

order to do this, certain allowance must be made for some filler. Mixtures showing 25 to 50 pounds of filler may in reality not contain filler at all, but be made up by using slightly more of the different fertilizer materials called for. So, practically 25 or 50 pounds of filler should be disregarded. But amounts above, say 60 pounds, are not necessary.

In order to bring out this point we have asked C. G. Owen, Honolulu manager of the Pacific Guano & Fertilizer Company, to briefly outline the mixing of concentrated goods from the manufacturers' point of view.

Mr. Owen submitted his views as follows:

The manufacturer recognizes without question the advantage of using highest concentrated mixed fertilizers where unit values of nitrogen, phosphoric acid and potash are constant, because the cost of application becomes less by reason of less labor, less freight and less bags per unit of plant food applied. In compounding a ton of commercial high grade fertilizer it is not practical to figure closer than 97 per cent of ingredients, thus allowing 3 per cent for nitrogen, phosphoric acid and potash content in excess of the guarantee. We believe the reason for this is quite clear, but as an example we will say that if a formula is called for as follows:

12% Nitrogen—6% sulphate
5% nitrate
1% organic
6% Phosphoric Acid—3% bonemeal
3% superphosphate
6% Potash—from sulphate, muriate or nitrate

the manufacturer could not take the risk of using only sufficient materials equal to exactly the guarantee, because it would be practically impossible to draw samples of this mixture which would analyze up to the guarantee of each ingredient. The materials themselves from which such a fertilizer would be composed have different specific gravities, and when mixed together even with the greatest care will not retain their relative position within the mass, but tend to separate according to their different specific gravities; the heavier materials gradually shifting from position in the handling of the goods from the upper part of the bag in which they are transported and the lighter materials coming to the top. Even should their position remain undisturbed, the ordinary commercial laboratory control and analyses are not sufficiently accurate to secure positive results within one- or two-tenths of a per cent. Therefore, should the manufacturer figure to fill the guarantee exactly the chemical analysis would show a certain range, one element higher than guaranteed while other elements would be below the guarantee, and should it just so happen that the averages were in phosphoric acid and potash, the less valuable plant foods, and the shortage be in nitrogen, the manufacturer would be subject to a continuous lot of claims for shortages which did not actually exist. Thus it is evident, we think, that no commercial fertilizer could be figured closer than 97 per cent or 1940 pounds to the ton.

In regard to certain of the formulas reported, which show fillers of from 200 to 400 pounds, by a strict calculation rather than by practice, these additions to the make-up do not always exist except by the nature of the raw materials used, because phosphatic materials and organic nitrogen materials are far from standard, and there is sufficient range in the analyses of these raw materials to take care of the so-called filler to a large degree, for commercial bonemeal comes to the manufacturer ranging in analyses from 21 per cent phosphoric acid to 31 per cent phosphoric acid, superphosphate from 16 per cent to 20 per cent; dried blood and tankage also have great variations, consequently manufacturers in filling what might be termed a lower grade formula than the usual high grade make use of the lower grade material thus obviating the necessity of adding much filler.

The fertilizer manufacturer would welcome an adoption of the general principle of the consumer using highly concentrated mixed fertilizers because the maximum good could be obtained from the least tonnage and a fertilizer plant could be established to handle the least number of tons to get the greatest benefit.

As newer and higher concentrated raw materials are produced at prices equal to present cost of materials which are now available in the market and in regular supply, the concentration of fertilizezrs can be raised. For instance, when ammonium nitrate and ammonium phosphate, urea and potassium nitrate can be produced as cheaply as present materials are produced, then higher concentrated goods can come into general use. At the present time these materials are limited in quantity and the cost is generally so high that the use of them offsets the savings in freight, labor and bags as first mentioned.

We would say that at the present time commercial fertilizer calculated to within 90 per cent of the possible concentration would be economically sound, for we will assume that freight, bags and handling have a combined average value of $10 per ton, 3 per cent of this value would have to be allowed for a laboratory analyses margin, as previously explained, leaving 7 per cent or the equivalent to 70 cents per ton, which might be saved by the elimination of all fillers.

In calculating the formulae given under mixed fertilizers at the beginning of this article, the following analyses were used:

Ammonium sulphate	20.5% N	....
Nitrate of soda	15.5% N	....
Nitrate of potash	14.0% N	14% K_2O
Bone meal	3.5% N	22% P_2O_5
Superphosphate		19% P_2O_5
Sulphate or muriate of potash		50% K_2O
Dried blood	13.0% N	....

In order to make this report complete, some of the details of the fertilizer practices on the various plantations are given herewith:

1. What is the total amount per acre used? If you use different quantities on plant and ratoons (long and short) on mauka and makai or good and poor fields, please give the various amounts. Please state briefly your policy in regard to the amounts used in various fields.

Olaa Sugar Company, Ltd.: We use 1,750 pounds per acre. We make no difference. All fields get the same amount.

Waiakea Mill Company: Standard application is 1,250 pounds per acre. All plant cane receives this amount. On ratoons, the amount is varied from 750 pounds per acre to 1,750 pounds per acre, depending on the condition of the stools. It is our policy to give heavier applications to better cane and lighter applications to poorer fields.

Hilo Sugar Company: We use 500 pounds B-1 per acre throughout the entire area.

Application Plan—Hilo Sugar Co.

Ratoon

Application	Lbs. Fertilizer	Lbs. Nitrogen	Lbs. Potash	Lbs. Phos. Acid
1st	125 P–N	18¾	12½	....
2nd	500 B–1	60	50	25
3rd	375 P N	56¼	37½	....
Spring	500 P N	75	50	....
Total	1500	210	150	25

Plant

1st	250 B–1	30	25	12½
2nd	250 B–1	30	25	12½
3rd	500 P N	75	50	. . . .
Spring	500 P N	75	50	. . . .
Total	1500	210	150	25

Onomea Sugar Company: We use 1,500 to 1,800 pounds per acre per crop. All pretty much alike, but somewhat heavier on the knolls than the hollows.

Pepeekeo Sugar Company: Different quantities are used according to condition of growth. The poorer upper lands receive 1 to 2 bags per acre. More than good lands as a rule.

Honomu Sugar Company: We use 1,125 pounds—the same amount for both plant and ratoons.

On the mauka fields fertilization is not as heavy if the crop does not warrant it.

Hakalau Plantation Company: We use from 1,200 to 1,500 pounds per acre, this amount applies to both mauka and makai lands.

I don't think it good practice to cut down on the amount applied to your good fields, and increasing the amount on poor soil.

By applying a good amount of fertilizer to your good soil, the fertilizer has something to work on, and your returns are very much increased. Whereas increasing the amount on poor light soil, you stand a chance of losing a lot of it, by being washed away by rain, and it is completely lost.

Laupahoehoe Sugar Company: 1,000 to 1,200 pounds high grade; 500 to 700 pounds nitrate. Applications depending on conditions.

Kaiwiki Sugar Company, Ltd.: We use 1,250 pounds.

Hamakua Mill Company: We use 1,000 pounds.

Paauhau Sugar Plantation Company: From 800 to 1,200 pounds nitrate of soda, 15.5 per cent N. From 0 to 250 pounds bonemeal, 22 per cent P. From 0 to 150 pounds potash from molasses, 25 per cent K.

Amounts applied to various mauka or makai fields depend upon the general appearance and stand of cane, drought conditions that may affect second season fertilization, and the fertility of the field in general as judged by previous crop yields.

Niulii Mill and Plantation: 1,000 pounds high grade, 250 to 300 pounds nitrate.

Halawa Plantation, Ltd.: From 800 to 1,000 pounds per acre, according to location and stand of cane. On short ratoons, we sometimes use 300 pounds sulphate of ammonia and 600 pounds nitrate of soda, applied in three doses, by hand.

Kohala Sugar Company: We use 1,250 pounds. Ratoons and plant treated alike.

Union Mill Company: Five hundred pounds applied per acre in one dose, as a rule. This may be increased to 750 pounds per acre on the better fields.

Hawaiian Agricultural Company: From 1,200 pounds to 1,700 pounds. No difference made with plant or ratoon, nor yet mauka or makai. We, however, make a difference with some of our fields, depending upon the natural fertility. These we are generous with, but as a rule curtail our amounts upon fields where moisture is uncertain.

Hutchinson Sugar Plantation Company: The amount varies according to the fields. We apply more on our good fields than we do on our poorer fields and 1,000 pounds to 1,500 pounds per acre is applied.

Kaeleku Sugar Company: One thousand pounds per acre is our standard application.

Healthy ratoons all in one dose. Backward and dried fields two doses of 500 pounds each. Plant cane 400 and 600 pounds in two applications.

Maui Agricultural Company, Ltd.: All fields get 625 pounds per acre.

Hawaiian Commercial and Sugar Company: We use 625 pounds per acre on both plant and ratoons. All fields fertilized the same.

Wailuku Sugar Company: Plant cane, 1,000 pounds in two applications. Ratoons, 1,000 pounds in one application. Short ratoons, none.

This practice determined from results of fertilizer experiments carried on in various parts of the plantation.

Olowalu Company: We use 1,000 pounds per acre on plant and long ratoons, and 750 pounds per acre on short ratoons.

Pioneer Mill Company, Ltd.: Last year we used sulphate of ammonia for first season with superphosphate also applied on our mauka fields, the lower fields getting nitrogen only. Both plant and ratoons are given equal amounts, 3½ bags or 437½ pounds of sulphate and 4½ bags or 567½ pounds of nitrate. This gives a total of 175 pounds of nitrogen. Mauka fields get in addition 3½ bags or 437½ pounds of superphosphate or 87½ pounds of P_2O_5.

Waianae Company: Total amount 150 pounds of nitrogen.

Ewa Plantation Company: No set rule; varies with

(a) Time of starting field;
(b) Time of harvesting field;
(c) Soil conditions;
(d) Stand of cane;
(e) Drainage conditions;
(f) Weed condition of field.

Total amounts vary from 175 to 275 pounds nitrogen.

Oahu Sugar Company, Ltd.: We use an average of 1,000 pounds an acre.

Honolulu Plantation Company: We use from 900 pounds to 1,000 pounds per acre on all cane.

Waimanalo Sugar Company: We use 875 pounds on plant and long ratoons. Short ratoons, we apply 250 pounds of nitrate of soda about 3 weeks after harvesting and follow with 625 pounds of high grade about 2 months later.

Kahuku Plantation Company: Long ratoons, 5 bags, 750 pounds. Plant, 5 bags, 750 pounds. Short ratoons, 3 bags, 375 pounds.

We make no deviation from the above figures on account of soil or crop differences.

Waialua Agricultural Company, Ltd.: We use the same amount on all fields—1,000 pounds high grade, 500 to 600 pounds nitrate of soda. I do not believe in adding more to the poor spots. Land that is considered poor should, if possible, be discarded or left fallow for a crop or two.

Kekaha Sugar Company: We use from 750 to 1,000 pounds per acre. All ratoon fields get a dose of 125 pounds of nitrate of soda per acre when, or shortly after, cane is cut; when 2 months old we apply high grade and after that we give 800 pounds of nitrate of lime or soda in 2 or 3 applications.

Waimea Sugar Mill Company: We use 1,000 pounds per acre on all fields.

Hawaiian Sugar Company: We use 1,000 pounds per acre on both plant and ratoons, and extra doses where cane is poor.

McBryde Sugar Plantation Company: We use 625 pounds mixed fertilizer per acre. Total nitrogen for crop received in fields varies from 150 to 225 pounds per acre. This depends on stand, soil, location, variety and the controlling factor here, viz: water. Good fields get more, poor fields less.

Koloa Sugar Company: Amount has been increased the last two years. Last year we applied 875 pounds per acre, this year we increased it to 1,000 pounds per acre. This is now applied regularly to all fields, the total nitrogen being varied according to field locations and soil types when second season applications are made. Mauka, unirrigated areas get less than more fertile irrigated areas. We try to govern our fertilization by results of experiments in typical soil types of the various sections. As available data is as yet meagre we are more or less playing safe with kind and amount of fertilizer. Mauka areas get 100 to 130 pounds nitrate per acre, makai areas 150 to 225 pounds per acre nitrate, and plant and ratoon fields with a strong stand get heavy doses; poorer cane lighter doses.

Lihue Plantation Company, Ltd.:

From 600 to 1,000 pounds for plant in our makai fields;
From 400 to 600 pounds for plant in our mauka fields;
From 400 to 600 pounds for long and short ratoons.

The amount varies according to the variety of cane and location of fields.

Kilauea Sugar Plantation Company: In good fields, about 800 pounds per acre. In poor fields less. This depends so much on condition of cane and time of year. If we have a good stand, free of weeds early in the summer we apply one big dose. If it is late in the fall when the cane is ready we wait until spring. In thin soils we apply less, in deeper soils more.

2. In how many doses is this fertilizer applied?

Olaa Sugar Company, Ltd.: 3-4-2 5 bags. The 2 bags dressing comes in the winter months.

Waiakea Mill Company: On plant cane two applications—1st 500 pounds, 2nd 750. On good ratoons one application of 1,250 pounds or one of 1,000 to 1,250 pounds, and the second of 500 pounds. On poor ratoons two applications—1st 500 per acre.

Hilo Sugar Company: One application on ratoons. Two applications on plant.

Onomea Sugar Company: Three; two in the first growing season and one in second. There are times when we apply three times the first season, depending on climatic conditions and if we get the fertilizer early in the season.

Pepeekeo Sugar Company: Generally in two applications.

Honomu Sugar Company: Two doses—above 1,200 feet elevation, three applications.

Hakalau Plantation Compny: Three doses on plant and two on ratoon.

Laupahoehoe Sugar Company: Three and four.

Kaiwiki Sugar Company, Ltd.: Two.

Hamakua Mill Company: Two.

Paauhau Sugar Plantation Company: From 2 to 4.

Niulii Mill and Plantation: Usually 3 applications.

Halawa Plantation, Ltd.: High grade in 2 doses.

Kohala Sugar Company: Two applications.

Union Mill Company: One.

Hawi Mill and Plantation Co., Ltd.: ....

Hawaiian Agricultural Company: Three.

Hutchinson Sugar Plantation Company: As a rule, 3 times.

Kaeleku Sugar Company: One and two, depending on the vigor of the crop.

Maui Agricultural Company, Ltd.: One.

Hawaiian Commercial and Sugar Company: One dose.

Wailuku Sugar Company: Plant cane 2 equal doses (500 pounds even), long ratoons 1 dose (1,000 pounds).

Olowalu Company: On plant and long ratoons 2 doses, on short ratoons 1 dose.

Pioneer Mill Company, Ltd.: Plant cane first season fertilizer applied in 2 doses, second season 1. Ratoon cane first season fertilizer applied in 1 dose and second season in 1 dose.

Waianae Company: Three.

Ewa Plantation Company: No set rule; varies as in Question 3. Not less than 2 doses, not more than 4.

Oahu Sugar Company, Ltd.: One dose for high grade.

Honolulu Plantation Company: Two doses.

Waimanalo Sugar Company: One.

Kahuku Plantation Company: One application.

Waialua Agricultural Company, Ltd.: One dose for high grade and one dose for nitrate.

Kekaha Sugar Company, Ltd.: One dose.

Waimea Sugar Mill Company: One.

Hawaiian Sugar Company: Very young cane 2 doses. Cane 4 months old, one dose.

McBryde Sugar Plantation Company: One.

Koloa Sugar Company: In most cases of late we put on 1,000 pounds in one dose and find results warrant it.

Lihue Plantation Company, Ltd.: One.

Kilauea Sugar Plantation Company: One dose on plant. Usually 2 doses on ratoons.

3. Do you always make it a policy to weed your fields before applying the fertilizer, or when the proper time comes do you fertilize, regardless of the condition of the field, rather than unduly delay this application?

Olaa Sugar Company, Ltd.: Yes, although when there is an acute shortage of labor, as in 1921, we are not very particular.

Waiakea Mill Company: We always weed our fields before applying fertilizer, even if this causes some delay in time of application.

Hilo Sugar Company: We always weed our fields before fertilizing.

Onomea Sugar Company: We never apply fertilizer to weedy fields unless it is the intention to cover everything up immediately, such as hilling up.

Pepeekeo Sugar Company: Where possible, but have found good results from applying a week ahead of hoeing as the cane gets hold of the fertilizer and makes a rapid growth and gets well ahead of the grass after hoeing, thus widening the period between hoeings.

Honomu Sugar Company: We always weed the fields previous to applying fertilizer.

Hakalau Plantation Company: We always endeavor to clean our fields before applying fertilizer but do not believe in delaying the application.

Laupahoehoe Sugar Company: We weed before applying fertilizer.

Kaiwiki Sugar Company, Ltd.: Always clear fields before fertilizing.

Hamakua Mill Company: When clean.

Paauhau Sugar Plantation Company: We do not fertilize unless field has been weeded, and like to see our way of keeping field clear after fertilizing. Do not believe in applying fertilizer unless cane is reasonably free from weeds and pretty well closed between rows for second season fertilization.

Niulii Mill and Plantation: We make it a policy to weed the fields first.

Halawa Plantation, Ltd.: We always weed before applying fertilizer.

Kohala Sugar Company: If necessary, we always hoe our weeds before applying fertilizer.

Union Mill Company: Fertilizer is applied to clean fields only.

Hawaiian Agricultural Company: Never apply fertilizer unless fields are clean.

Hutchinson Sugar Plantation Company: We always weed our fields before fertilizing.

Kaeleku Sugar Company: Weed the fields. We would not apply otherwise regardless of how late the application.

Maui Agricultural Company, Ltd.: As a general rule fertilizers are not applied when the fields are in a weedy condition.

Hawaiian Commercial and Sugar Company: We weed and have the fields clean before fertilizing.

Wailuku Sugar Company: Fields are clean before fertilizer is applied.

Olowalu Company: Yes, always weed before fertilizing.

Pioneer Mill Company, Ltd.: We weed our fields before applying fertilizer, if possible.

Waianae Company: Weed whenever possible.

Ewa Plantation Company: Never apply fertilizer except in a clean field.

Oahu Sugar Company, Ltd.: Have fields clean whenever possible.

Honolulu Plantation Company: Always weed the fields first.

Waimanalo Sugar Company: Weed before applying fertilizer.

Kahuku Plantation Company: Always weed the fields and make an extra thorough weeding of reservoir and supply ditches.

Waialua Agricultural Company, Ltd.: We make it a point to have our fields clean and in good condition before applying fertilizer.

Kekaha Sugar Company, Ltd.: As a rule we weed before we fertilize. We would rather delay application than fertilize in dirty fields.

Waimea Sugar Mill Company: Applied on clean fields when possible.

Hawaiian Sugar Company: It is very important to have fields of sugar cane clean and free of weeds before fertilization and we make this a practice.

McBryde Sugar Company, Ltd.: Try to get fields weeded. Personal belief is to get fertilizer on even though field is weedy, if proper moisture assured, and if labor is such that weeds can be gotten soon. If rains come all plantation fields cannot get application at once.

Koloa Sugar Company: Where weeds are not heavy we often apply the fertilizer when cane is well up and able to keep ahead of grass. Labor permitting, we try to have weeding sufficiently advanced so as not to delay the fertilizer application. Whenever we can we weed ahead of the fertilizer application.

Kilauea Sugar Plantation Company: We weed first or sometimes apply the fertilizer directly ahead of the weeding.

Lihue Plantation Company, Ltd.: We prefer to have our fields clean.

4. How long before harvesting a field do you apply the last fertilizer?

Olaa Sugar Company, Ltd.: About 9 months.

Waiakea Mill Company: We apply nitrate as long as possible before harvesting. It usually runs from 9 months to a year ahead.

Hilo Sugar Company: As early as the size of cane will permit, but never later than a year before harvesting.

Onomea Sugar Company: Ten to 12 months or more. We aim to be through with our second year fertilization by the beginning or the end of May.

Pepeekeo Sugar Company: Twelve months if possible.

Honomu Sugar Company: From 8 to 10 months.

Hakalau Plantation Company: We endeavor not to fertilize after May, all our spring dressing is done between February and May.

Laupahoehoe Sugar Company: Five or 6 months.

Kaiwiki Sugar Company, Ltd.: One year.

Hamakua Mill Company: One year.

Paauhau Sugar Plantation Company: About 12 months.

Niulii Mill and Plantation: Ten to 12 months.

Halawa Plantation, Ltd.: About a year.

Kohala Sugar Company: At least 10 months before cutting.

Union Mill Company: At least a year.

Hawi Mill and Plantation Company, Ltd.: Our aim is not later than 10 months.

Hawaiian Agricultural Company: About a year; sometimes, owing to inability to harvest, 18 months.

Hutchinson Sugar Plantation Company: At least a year and often more.

Kaeleku Sugar Company: Eight months.

Maui Agricultural Company, Ltd.: Usually 9 to 12 months.

Hawaiian Commercial and Sugar Company: For the 1925 crop we finished applying nitrate of soda in March.

Wailuku Sugar Company: At least 12 months. Runs from 12 to 18 months.

Olowalu Company: Ten to 12 months.

Pioneer Mill Company, Ltd.: One year if possible.

Waianae Company: Long ratoons in June, short ratoons in January.

Ewa Plantation Company: Try to apply it at least 12 months before harvesting, but in December and January harvested fields the interval is 10 months.

Oahu Sugar Company, Ltd.: Eight to 12 months.

Honolulu Plantation Company: Nine to 18 months.

Waimanalo Sugar Company: At least a year.

Kahuku Plantation Company: June is the last date of general application. Harvest commences in December of the same year.

Waialua Agricultural Company, Ltd.: Five or 6 months (?), 10 to 12 months.

Kekaha Sugar Company, Ltd.: As a rule 6 months, sometimes less on short ratoons.

Waimea Sugar Mill Company: About 10 months.

Hawaiian Sugar Company: From 5 to 6 months.

McBryde Sugar Plantation Company: From 10 to 12 months.

Koloa Sugar Company: We try to make it as near a year as possible.

Kilauea Sugar Plantation Company: Not less than 9 months.

Lihue Plantation Company, Ltd.: We aim to have all our fertilizer in before June 15.

5. Do you practice so-called winter fertilization? What is your opinion in regard to this?

Olaa Sugar Company, Ltd.: Sometimes we apply a 2-bag dressing to some of our fields. We believe it keeps the plant growing and increases its root system, thereby putting it into a condition to readily absorb the spring dressing.

Waiakea Mill Company: No.

Hilo Sugar Company: Yes, we fertilize throughout the year. It is true that cane grows very slowly during the winter months, but if we do not apply fertilizer in the required amounts and at the proper time, the cane becomes very yellow and shows the need of same in winter as well as in summer.

Onomea Sugar Company: The only time we do this is when we are not able to get our regular work done sooner, not from choice. We believe it would be bad practice in this wet district.

Pepeekeo Sugar Company: Prefer to have some warmth and bacterial action in the soil before applying. Generally start second season's fertilization about March.

Honomu Sugar Company: Just as little as possible. In my opinion it is not good practice to fertilize during the winter months. The cane can make but little use of the fertilizer and there is more or less loss of nitrogen on account of the heavy rains of the winter season.

Hakalau Plantation Company: Most of our final or third application of fertilizer is done in winter months.

Laupahoehoe Sugar Company: We fertilize at any or all times when we consider necessary.

Kaiwiki Sugar Company, Ltd.: No.

Hamakua Mill Company: Sometimes; this depends on the season.

Paauhau Sugar Plantation Company: We believe that temperature is the limiting factor for cane growth during winter months. Lower fields, however, can be pushed ahead, if late, by fertilization every two months, if necessary.

Niulii Mill and Plantation: We prefer applying during summer months, but in the Kohala district on unirrigated fields it is usually too dry during those months, so we apply as soon as rain comes.

Halawa Plantation, Ltd.: ....

Kohala Sugar Company: We aim to have all fertilizing done by the middle of February.

Union Mill Company: No.

Hawi Mill and Plantation Company, Ltd.: No.

Hawaiian Agricultural Company: We apply so-called "spring dressing" at all times of the year. We do not believe in winter applications if it can be avoided.

Hutchinson Sugar Plantation Company: We fertilize at all times of the year. This is necessary under our conditions, where we harvest all the year.

Kaeleku Sugar Company: We do not approve of winter fertilization, and consider it more advantageous to defer fertilizing until spring.

Maui Agricultural Company, Ltd.: No.

Hawaiian Commercial and Sugar Company: ....

Wailuku Sugar Company: Yes, it is good practice for Wailuku. All fertilizer is applied before end of January—usually by December in order to get benefit of winter rains. Cane is usually closed in by this time and growth is stimulated by the fertilizer. Have better growth on cane since this has been made standard practice here.

Olowalu Company: We apply nitrate of soda on plant and long ratoons from early in January into March.

Pioneer Mill Company, Ltd.: We apply our spring dressing beginning in December and are through in March, most of the fertilizer going on in January and February. This gives us very good results.

Waianae Company: Yes. We have good results from winter fertilization.

Ewa Plantation Company: On early started cane, will apply a small October dose and get results which are profitable, as shown by experiments.

Oahu Sugar Company, Ltd.: No.

Honolulu Plantation Company: Have not tried it.

Waimanalo Sugar Company: No.

Kahuku Plantation Company: Nitrate of soda, 200 pounds per acre. Yes, very beneficial at Kahukū as it appears to assist cane to withstand the wet, cold climatic conditions of this side of the island. The test carried out this year is showing great benefit of this application.

Waialua Agricultural Company, Ltd.: We are opposed to winter fertilization, as it has a tendency to make the cane very soft and more susceptible to sickness.

Kekaha Sugar Company, Ltd.: Sometimes in a dry year. Nitrate of lime in the winter months, with good results. However, only in a dry year in the irrigation water.

Waimea Sugar Company: Depending on weather conditions. In case of a dry, warm winter it gives the cane a quick start in the spring.

Hawaiian Sugar Company: Yes, under certain conditions, it is a great help to backward fields, and in our opinion is worth the expense in certain cases.

McBryde Sugar Company: Yes. Depends on the winter. Think that a "shot" in November sends it along through the winter a bit. We start our spring dressing here in January.

Koloa Sugar Company: Some fields which have received very early mixed fertilizer applications show apparent gain in color and growth with additional dose of nitrate in late fall or early winter. We have not done this extensively yet.

Kilauea Sugar Plantation Company: No. It is very dangerous with us, since we get no response in a cold and wet winter.

Lihue Plantation Company, Ltd.: The only winter fertilizing we do is in some late planted field, when we give 200 or 250 pounds of nitrate of soda to stimulte it through the cold weather.

6. How do you apply mud press to plant fields before plowing, to poor spots in different fields, etc.?

Olaa Sugar Company, Ltd.: It depends on the nature of the soil. In some fields it is used for "touching up" poor spots, in others it is spread evenly all over.

Waiakea Mill Company: We apply to plant fields before plowing when such fields are adjacent to railroad. Otherwise to ratoon fields. We do not believe in spending large amounts doctoring up poor spots. The same amount spent on good soil will produce double the results.

Hilo Sugar Company: We apply it to plant fields before plowing and to poor spots in all fields as far as is practicable.

Onomea Sugar Company: Our preference is to have it plowed in before planting, but we find it good in every instance no matter how it is applied, only when it is plowed under it saves the forcing of weeds. All surface weeds feed readily on it, hence we prefer

turning it under. We also get good results by applying it in the furrow just before planting.

Pepeekeo Sugar Company: As much as we can get on plant ahead of plowing, the remainder to poor spots or poor fields.

Honomu Sugar Company: To plant before plowing and to poor spots in both plant and ratoon fields.

Hakalau Plantation Company: We get as much as possible on fields to be planted, and also before plowing. On ratoons we spread it in between the rows.

Laupahoehoe Sugar Company: Before plowing; also throughout the different fields.

Kaiwiki Sugar Company, Ltd.: Before plowing.

Hamakua Mill Company: Before plowing to poor fields.

Paauhau Sugar Plantation Company: Mostly by throwing it into the irrigation water.

Niulii Mill and Plantation: To poor spots in fields.

Halawa Plantation, Ltd.: To plant fields before plowing and to poor places, such as hillsides, etc.

Kohala Sugar Company: We apply it on poor spots and plow in, but mostly to young crops in irrigation water.

Union Mill Company: To plant fields before plowing.

Hawi Mill and Plantation Company, Ltd.: To plant fields before plowing.

Hawaiian Agricultural Company: Poor spots. In ratoon fields.

Hutchinson Sugar Plantation Company: ....

Kaeleku Sugar Company: Poor spots in stony fields.

Maui Agricultural Company, Ltd.: ....

Wailuku Sugar Company: To both. Applied to fields convenient for transportation on railroad.

Olowalu Company: Generally on poor spots in fields while portable track is in the field.

Pioneer Mill Company, Ltd.: We would like to apply all mud press to our mauka fields which are low in phosphoric acid, but the handling costs prohibit this. Most of our mud press is spread with manure spreaders ahead of second steam plowing. Poor spots are also touched up with mud press.

Waianae Company: Both.

Ewa Plantation Company: Uniformly by manure spreader.

Oahu Sugar Company, Ltd.: Before plowing; also to poor spots and in water when necessary.

Honolulu Plantation Company: To plant fields before plowing.

Waimanalo Sugar Company: To plant fields before plowing if fields are available; if not, in irrigation water.

Kahuku Plantation Company: 1. To different fields in the water (mostly coral rock sectors). 2. To fields lying fallow. 3. To poor spots.

Waialua Agricultural Company, Ltd.: Prefer applying it to fields before plowing or after the first plowing.

Kekaha Sugar Company, Ltd.: We apply by railroad cars from 10 to 15 cars, or about 10 to 15 tons per acre, and plow under.

Waimea Sugar Mill Company: Either to plant fields before plowing, or to poor spots in different fields.

Hawaiian Sugar Company: We apply it in the irrigation water, and also before plowing.

McBryde Sugar Company, Ltd.: Plowing, but where possible like to get it on poor spots. We often run it in water on poor spots, especially if the fields to be plowed are too far and inconvenient from main line.

Koloa Sugar Company: We apply it with a manure spreader on fields to be plowed and planted.

Kilauea Sugar Plantation Company: Plant fields before plowing; also on poorer spots and palis in ratoon fields.

Lihue Plantation Company, Ltd.: Yes.

Comparative Values of Normal Juice Factors*

By Raymond Elliott

The methods used for determining the tons of cane in a factory where the cane is flumed directly to the crusher necessitates the use of a factor on the crusher or first mill juice brix, so that the various calculations can be made.

We know that as the cane comes to the mill to be ground, it is very difficult to sample because of the widely varying degrees of ripeness. Therefore, on rail and flume plantations the control starts at the mixed juice scales.

It has been found that in flume cane factories the first expressed juice is diluted with water adhering to the cane, and in determining a factor to be used in calculating the weight of the cane allowance has been made for this dilution, that is, the calculated cane weight refers to dry cane or rather to cane minus adhering water, but not water that has been absorbed by the cane, which becomes a part of the juice in its transit from field to mill.

The cane weight on a flume plantation, where a constant factor is used will not vary as on a rail plantation where the cane is weighed. The rail weights will vary according to climatic conditions, trash content of cane and its ability of retaining water. In some cases where there is a flume near the mill, a train of cane may come directly to the scale and be weighed while there is considerable water still dripping from the cars. This extra weight goes in as cane and increases the tonnage of cane, making the ratio of cane to commercial sugar higher. On flume plantations these fluctuations do not occur, therefore, they have the advantage.

The object of the writer is to make a brief comparison of normal juice factors in order that we may see how important this phase of control is. The whole question may be summed up as follows:

First, how important is the normal juice factor?

Second, the weight of cane per ton of sugar being intimately tied up with the normal juice, will the tons of cane per ton of sugar from a fluming plantation be strictly comparable with a factory that weighs their cane?

Third, is there any relation between Java ratio and the normal juice factor?

I have taken an ordinary day's run at Paauhau and calculated the tons cane by using different factors. The table, which is to a large extent self-explanatory, is given herewith:

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

AVAILABLE DATA APRIL 1ST, 1924

Brix of Crusher Juice	17.00
Polarization of Crusher Juice	14.80
Purity of Last Mill Juice (Discharge Roller)	67.82
Purity Mixed Juice	82.66
Fiber per cent Cane	12.81
Moisture per cent Bagasse	37.92
Polarization per cent Bagasse	1.35
Tons Polarization in Mixed Juice	76.91
Tons Polarization in Cane	78.86
Polarization per cent Cane	11.60
Extraction of Polarization per cent Polarization in Cane	97.53
Tons Cane Weighed	679.88
Normal Juice Factor Calculated	95.06
Java Ratio	78.38

CALCULATIONS USING DIFFERENT NORMAL JUICE BRIX FACTORS

Factors Used	92	93	94	95	96	97	98	99	100	101	102	103	104
Normal Juice Brix	15.64	15.81	15.98	16.15	16.32	16.49	16.66	16.83	17.00	17.17	17.34	17.51	17.68
Normal Juice Polarization	12.96	13.00	13.14	13.28	13.43	13.56	13.70	13.84	13.98	14.12	14.26	14.40	14.54
Normal Juice Purity	82.20	82.20	82.21	82.21	82.22	82.22	82.23	82.23	82.24	82.24	82.24	82.25	82.25
Polarization per cent Cane	11.21	11.33	11.46	11.58	11.71	11.82	11.95	12.07	12.19	12.31	12.43	12.56	12.68
Extraction of Pol'n per cent Pol'n in Cane	97.41	97.44	97.47	97.50	97.52	97.55	97.57	97.60	97.62	97.64	97.67	97.69	97.71
Tons Polarization in Cane	78.95	78.93	78.91	78.88	78.87	78.84	78.83	78.80	78.79	78.77	78.74	78.73	78.71
Tons Cane	704.28	696.65	688.57	681.17	673.53	667.01	659.67	652.86	646.35	639.87	633.47	626.83	620.74
Java Ratio	75,74	76.55	77.43	78.24	79.12	79.86	80.74	81,55	82.36	83,18	83.99	84.86	85.68

Inspection of the figures show, that the higher the normal juice factor, the higher the extraction and polarization per cent cane, also less tons of cane, therefore less tons of cane per ton of sugar and furthermore, as the normal juice factor is increased, the Java ratio increases in proportion. Lowering of the normal juice factor reverses the above.

Assuming a 90 per cent total recovery, we have for a 92 normal juice factor, $78.95 \times .90 = 71.05$ tons sugar, and calculated tons of cane per ton of sugar is 9.91 and similarly for a factor of 104 we have $78.71 \times .90 = 70.84$ equalling 8.76 tons of cane per ton of sugar.

The difference, or 9.91 less 8.76, is 1.15 tons of cane, or .09 ton cane per degree increase or decrease in normal juice factor depending on whether the factor is increased or decreased.

If the fiber is decreased, other factors remaining constant, the extraction and polarization per cent cane are increased, with a correspondingly less tonnage of cane, hence less tons of cane per ton of sugar. Increasing the fiber, the reverse is true.

The writer calculated all of the normal juice factors for the different plantations from figures given in the Annual Synopsis of Mill Data for the years 1921, 1922 and 1923. The factors and Java ratios were plotted and agreed very closely when compared year by year. The graph for 1923 is given. Each plantation, however, is not strictly comparable with another for this reason. Some mills report only crusher juice while others report a mixture of crusher and first mill juice. The latter is generally called first mill juice. The crusher juice will roughly represent a juice extraction of 30 per cent while the crusher and first mill may go as high as 30 per cent juice extraction.

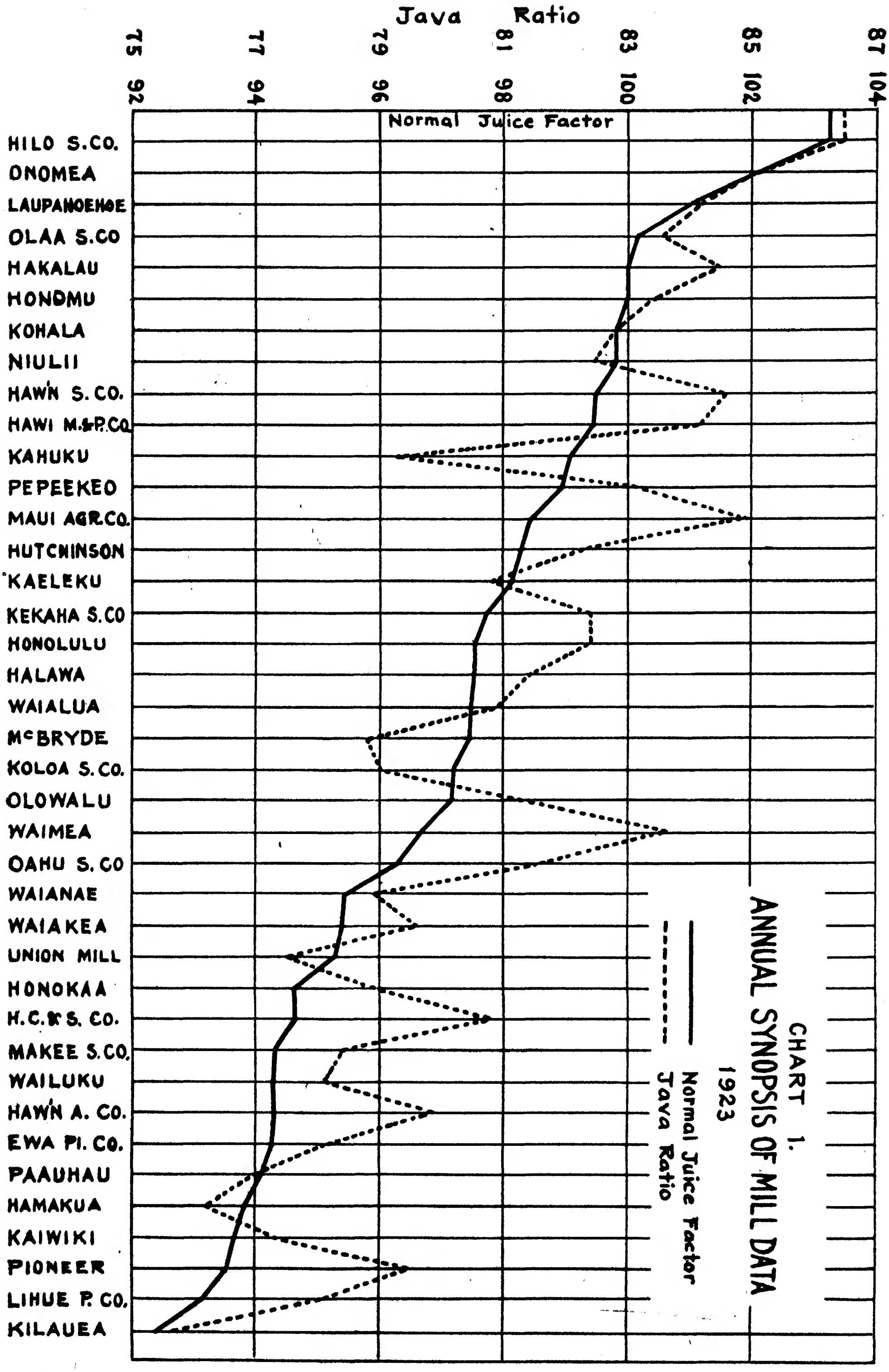
At Paauhau, we have made a large number of determinations to ascertain the difference between the crusher and first mill brix. An average of 97 tests gave the following:

Crusher juice brix....................................	16.81
First mill juice brix....................................	16.48
Difference	.33

On this basis, each tenth in brix would then represent $\pm$ .59 in the normal juice factor where the brix is 17.00 and $\pm$ .50 where the brix is 20.00. The difference does not seem large, but when calculating tons of cane using these differences, large discrepancies appear.

On a plantation where the cane is weighed, it has been my experience that the calculated factor varies from day to day. Today it may be 94, tomorrow 98, and no visible reason for the change, but, over a long period, comparing crop to crop, the factor is quite constant.

Following are some figures taken from the daily reports at Paauhau. They tend to show that rainfall influences the normal juice factor:


Java Ratio
75 77 79 81 83 85 87
92 94 96 98 100 102 104
Normal Juice Factor
HILO S.CO.
ONOMEA
LAUPAHOEHOE
OLAA S.CO
HAKALAU
HONOMU
KOHALA
NIULII
HAW'N S. CO.
HAWI M.&P.CO.
KAHUKU
PEPEEKEO
MAUI AGR.CO.
HUTCHINSON
KAELEKU
KEKAHA S.CO
HONOLULU
HALAWA
WAIALUA
McBRYDE
KOLOA S.CO.
OLOWALU
WAIMEA
OAHU S.CO
WAIANAE
WAIAKEA
UNION MILL
HONOKAA
H.C.&S. CO.
MAKEE S.CO.
WAILUKU
HAW'N A. CO.
EWA PI. CO.
PAAUHAU
HAMAKUA
KAIWIKI
PIONEER
LIHUE P. CO.
KILAUEA
CHART 1.
ANNUAL SYNOPSIS OF MILL DATA
1923
Normal Juice Factor
Java Ratio

Date—1924	Rainfall in Inches	Normal Juice Factor	Java Ratio
March 24	1.49	99.70	81.66
March 25	.02	100.32	81.85
March 26	.01	98.82	80.50
March 27	.00	97.70	77.86
March 28	.36	94.62	79.31
March 29	.05	98.73	80.14
April 1	.00	95.06	78.38
April 2	.00	95.55	79.58
April 3	.00	95.76	77.17

When we have dry weather at Paauhau, generally the factor varies between 95 and 96, but as soon as it rains the factor rises. I think this may be due to the first expressed juice being diluted, hence a lower brix and polarization, the purity remaining constant. The total polarization in the cane would be the same as before.

I would not say that rainfall had everything to do with the variation of the factor. There are other conditions which to a greater or lesser extent influence the above, for instance, whether the cane is plant or ratoon, variety, damaged cane by rats and borer, irrigated vs. non-irrigated, etc.

The true average of 25 complete dry crushing tests at Paauhau gave a 95.17 normal juice factor based on the crusher juice. The same calculated on the combined crusher and first mill juices gave 96.67.

Summing up, in answer to the first question as to the importance of the normal juice factor, I would say that as far as the comparative value of the normal juice factor is concerned, it is quite useless to compare factory against factory under the existing conditions. If all factories were operating exactly alike, then the factor would be one of the most important figures that we could have in the chemical control for cane sugar factories in Hawaii.

To the second question, as long as flume cane factories calculate their cane weights and all use different normal juice factors, their tons of cane per ton of sugar will not be comparable with those factories weighing their cane.

Lastly, the Java ratio is important as there is a direct relationship between the two figures.

In concluding this discussion on normal juice factors, I think more time, attention and thought should be given this important subject and that its value be frequently determined by all plantations on a uniform basis.

Report on Mill and Boiling House Installations and Activities in 1924*

By Arthur F. Ewart

In the early part of July letters were addressed to a number of mill engineers asking for a list of new machinery that was being installed in their factories this year, also for any other information that would be of interest to the members of this Association.

The six replies received form a part of this report.

J. Lewis Renton, of Ewa Plantation Company, writes:

The new machinery added to the Ewa Plantation Company factory this year has not been very extensive.

The main engine of the second mill train, which was a 28" x 48" light Corliss, was replaced by a heavy duty 30" x 54" Corliss, and the new engine is giving perfect satisfaction as well as increasing our recovery by being able to carry the load as now determined by Hawaiian mill practice. The variation from the standard 30" x 60" engine for a nine-roller mill unit was deemed advisable as this engine drives the second mill train, which operates at a comparatively high speed especially with our high grinding rate and to keep the piston speed within limits of good practice it was necessary to shorten the length of cylinder.

An electric magnet was installed back of the first nine-roller mill unit to remove iron from the bagasse blanket before entering the second nine-roller mill unit. The magnet was made part of the discharge roll scraper and set at an angle of 45°, and was very successful in catching and holding practically all of the iron and steel passing this point. This assortment was the accumulation of three months' grinding and weighed over 300 pounds. From the experience gained with this installation I do not at present see any hope of removing iron or steel preceding our mills or even early in the mill train, except at some point where a thin blanket of dry, finely divided bagasse is made to slide down an incline. These limitations make its adoption almost impossible except in those mills where such a condition does exist. I might add, that with our heavy tonnage, most of the damage to the rollers and the grooving from pieces of iron occurs in the second mill train.

Boiler feed water regulators of the Copes manufacture were tried out on four of our boilers and gave such excellent service that they are to be placed on all of our high pressure boilers. One advantage of this type of regulator is its simplicity, the only working part being the boiler feed valve itself and the lever to it. A fusible disk type of low water alarm is being used also.

Water meters were installed on the boiler feed, maceration water line, and the mud press wash water line. These are very satisfactory and a great help in the work and control of the factory.

The milk of lime for liming at the mixed juice scales, is now being circulated and mixed with an air lift operated by compressed air. While not as efficient mechanically as other means of circulation now employed, provided the other equipment is kept up mechanically, it probably pays for itself in cost of upkeep and average efficiency.

An attachment to our cane scales on the empty car side has been tried out for the past several months, same being an automatic registering device which will give direct

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

readings of from 0 to 5,000 pounds, and has given such a good account of itself that an order has been placed for another for the full car scale. In case of disability, the attachment can be disconnected and weighing with the beam scale taken up. The automatic attachment is not very expensive and seems to be doing accurate work as well as enabling the scale man to be more accurate in his reports.

J. Meinecke, of Maui Agricultural Company, Ltd., writes:

The following is a list of new machinery being installed at Maui Agricultural Company, Ltd., this season:

1 Westinghouse steam turbine direct connected to 1500 k. w. generator, turbine running 3600 r. p. m. condensing on an Alberger condensor.

1 Guild and Garrison juice pump 12" x 12" x 20".

1 Cameron boiler feed pump 16" x 10" x 33".

1 Double friction steel hoist for cane cars.

1 One hundred horse power motor for revolving cane knives.

1 One hundred and fifty horse power motor for revolving cane knives.

1 Eighty-eight-tooth, 4½" pitch, 18" wide mill gear.

1 Honolulu Iron Works mill, consisting of 2 cast steel cheeks with Honolulu Iron patent steel caps and cast steel returner bar for 7th mill.

4 Honolulu Iron Works patent steel caps for 5th and 6th mills.

12 New cast iron mill rollers 34½" x 66".

2 Eight hundred horse power Stirling boilers to carry 160 pounds steam replacing 6-7 x 20 tubular boilers. The factory will have a total of 3900 boiler horse power consisting of four 800 horse power boilers and two 350 horse power Badenhausen boilers, all to furnish steam at 160 pounds pressure for Westinghouse steam turbine and 125 pounds steam for factory through Mason regulating valves.

2 Ten-inch double automatic Lagonda steam valves.

2 Ten-inch Mason regulating valves to regulate pressure from 160 to 125 pounds.

R. B. Kay, of McBryde Sugar Company, Ltd., writes:

Our only new installation during the past crop was a Peck strainer, which gave very satisfactory results. A detailed report of the strainer will appear under "Raw Juice Straining."

New machinery being installed this year includes a 15-ton Niles electric crane, a new machine shop and a lathe capable of turning our own rolls. The machine shop is actually a cotinuance of the mill, and the electric crane will enable us to lift the roll direct to the lathe. From this arrangement we anticipate a considerable saving in labor and time.

George Duncan, of Olaa Sugar Company, Ltd., writes:

I am afraid I cannot give you any assistance on the above topic, as there is nothing new or contemplated at Olaa.

A subject that has received very little attention, it seems to me, is that of fuel economizers. Why is it they are not used, especially in places where they are troubled by the lack of fuel? Even in new factories their use is not contemplated. There must be some reason for this. What is it?

Maybe we may hear something at the meeting that will throw a bit of light on this.

W. van H. Duker writes:

Crusher Roll Design: The ordinary crusher roll consists of a shell fastened on a steel shaft. Keying up of the shaft requires much time and needs to be done with the greatest care and accuracy, as otherwise it may happen that the shell works loose.

The maker is expected to deliver such work under the highest guarantee, that is, when both shell and shaft are furnished by him. When this is not the case and when a new shell is to be fitted to an old shaft, or vice versa, he cannot assume the same responsibility because the quality of the material is then unknown to him.

The charges for putting on a new shell are often considered high, but when realizing the painstaking effort and skillful work required, it is clear that such work can only be done by expert and high-paid labor.

The location of the keyway in the pinion on one roll is done after the keyway in the other roll has been fixed, because the pinion must be so fitted that the corrugations on the shell and the teeth on the pinion correspond in their relative positions.

When the pinion has as many teeth as the shell has rows of corrugations, the key is placed opposite the center of a tooth in such a way that the center of the pinion tooth corresponds with the center of the corrugations on the shell.

The shape of the corrugations of the crusher shell has a decided influence on the quality of the crushing. In the illustration, Fig. 1, the space lettered A over 1 and 2

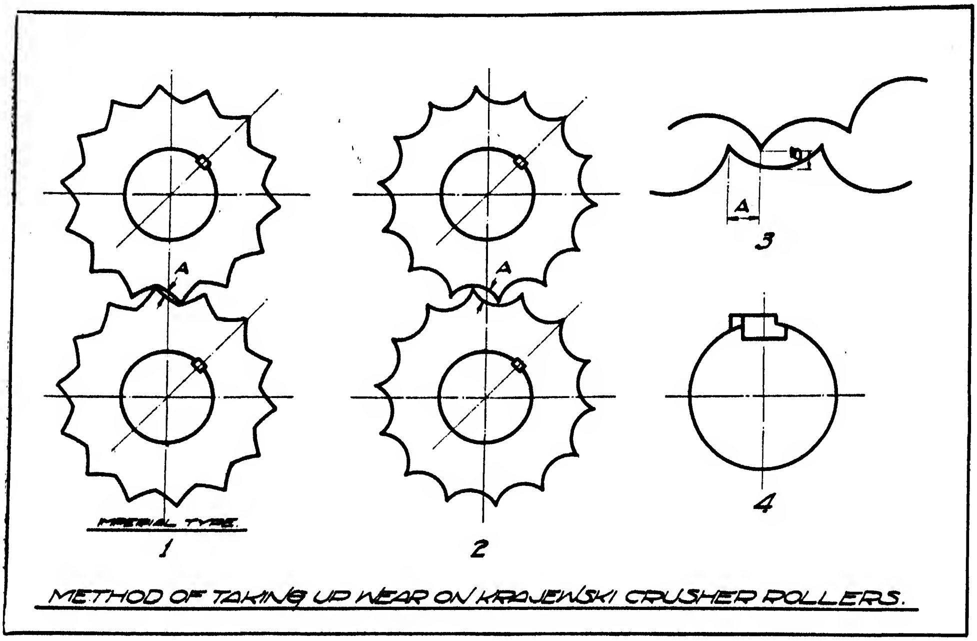


Fig. 1

is much smaller in the imperial type and the reabsorption of already removed juice is bound to be less.

When the corrugations on the shell are badly worn, the distance "A" can be reduced by changing the position of the pinion teeth in relation to the corrugations on the roll; this is done by using an offset key in the pinion, as shown in the illustration.

I present this case at the risk that I am repeating something considered as generally known, but I wish to add that this is an example taken from actual milling experience. At Hamakua Mill Company, this was exactly the case. For years the extraction obtained with a crusher and 12-roll mill remained at about 95 per cent. Many suggestions were made, many improvements executed, but the results were not changed. The crusher was badly worn and generally condemned until the local engineer, Wm. Craik, shifted the pinion on the shaft in the manner described above. From that time on entirely different milling results were obtained. I would say an average increase in extraction of between 1½ per cent to 2 per cent.

Mr. Seymour Terry writes:

Modern Evaporating Methods: Publications devoted to Sugar News point out a tendency in the European beet industry to discard our well established vacuum type evaporator in favor of pressure evaporation. The indication is that all new European beet factories under construction and contemplated will install evaporators operating at a pressure in the cells in place of a vacuum. They claim a saving of as high as 25 per cent of fuel used in certain cases by the adoption of this method of concentrating against the old method. It is natural that developments toward fuel saving should emanate from European beet factories when consideration is given to the fact that a beet factory has to purchase all the fuel used generally in the form of coal or oil, and Europe cannot afford to leave any suggestion of possible economy uninvestigated. Czechoslovakia is the most advanced in this new method of concentration, but Europe in general is prepared to discard the old for the new where conditions will allow of it. It is not the intention of this article to imply that any revolutionary changes can be effected by applying this system to our cane sugar factories, but simply to draw attention to what at this time is the leading topic in the camp of our beet sugar competitors.

It will be interesting to first set down the principle of operation of an evaporator.

In our standard multiple cell evaporator, we introduce steam into the calandria of the first cell, which steam contains both sensible and latent heat. We draw off the condensate at the temperature of the steam leaving behind the latent heat. This latent heat passes through the tube system and converts the liquid in the juice space into steam. This cycle is repeated for however many cells are used, such as four times in a quadruple effect evaporator. In order to have this latent heat pass through the tubes and do its work on the liquid it is necessary to have a difference of temperature between the heating steam and the liquid. This is obtained by using a condenser operated by cold water and an air pump to produce as low a temperature as possible in the last cell. The higher the vacuum the lower the temperature. The greater the temperature difference between the inlet steam and outgoing vapor or the overall temperature drop of the evaporator, the more work will be done by the evaporator. However, the act of condensing the vapor from the last cell throws into the discard all the remaining latent heat in the vapors.

In pressure evaporators it is general to use three cells as a triple effect operating at about 16 pounds pressure in the calandria of the first cell down to 1½ to 2 pounds in the vapor side of the last cell. This steam from the last cell is then used in the vacuum pans which operate at a vacuum as at present. The amount of steam required by the pressure triple evaporator is, of course, more than would be used in a quadruple operating at a vacuum, but in that it is discharged at such a pressure as to be of further use in the vacuum pans, a considerable steam saving is made. In this way, a unit consisting of a pressure operated triple supplying steam to the vacuum pans shows a large decrease in steam consumption over a quadruple and pans both operating at a vacuum. This new method gives a higher steam temperature and a correspondingly higher syrup temperature. To avoid discoloring the syrup, rapid circulating evaporators having a high transmission coefficient are used so that the concentration is rapid, and the time the liquor is in the apparatus short, which also means that the amount of liquor in the body at one time is much less than at present. Due to the condition that exists in syrup in that as the temperature increases, the viscosity rapidly decreases, a higher rate of evaporation is obtained for a given temperature drop at the higher temperatures of operation in the pressure evaporator. Incidentally, the engines supplying the exhaust steam to the evaporators have to work against a back pressure of 16 to 18 pounds per square inch.

Another phase of the evaporation problem which is being studied at this time is vapor compression described as follows:

The heating steam enters the calandria of the first cell and the condensate is drawn off as usual. The vapor produced from the liquid in the body of the cell and which is at a lower temperature than the heating steam, depending on whatever temperature drop the cell is operated at, is taken from the top of the cell and put through a vapor com-

pressor where it is compressed up to the pressure and therefore the temperature of the initial heating steam.

The methods employed to compress the steam are shown in Fig. 2:

A shows the standard quadruple evaporator as used in Hawaii in which the difference of temperature in the different cells is obtained by vacuum apparatus.

B shows a motor driven vapor compressor.

C shows a steam engine driven vapor compressor.

D shows a steam injector using live steam to compress the vapor.

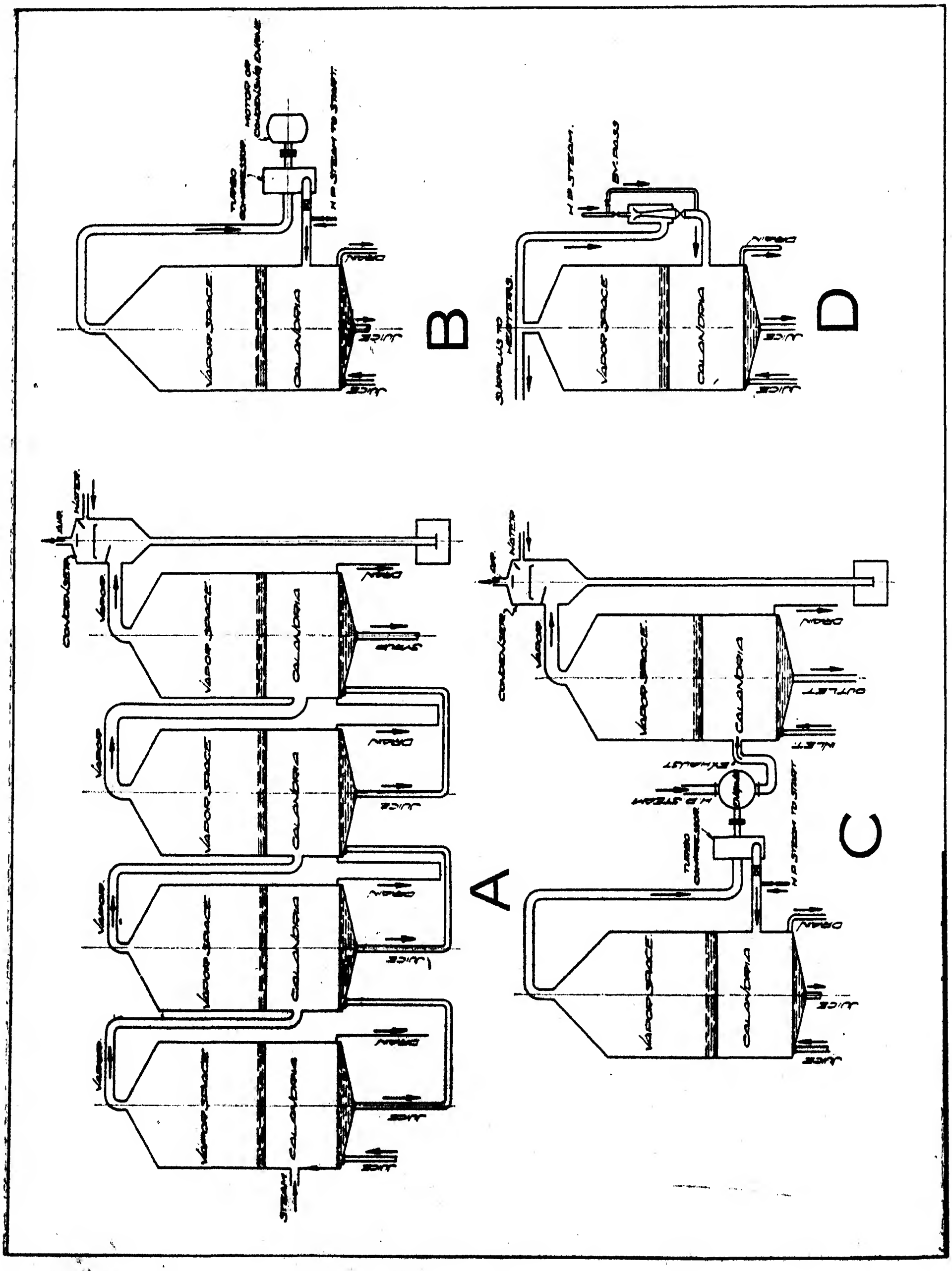


Fig. 2

The greater the amount of work obtained from a pound of steam, the lower the compression pressure, but this means a small temperature difference and large heating surface. The practical range appears to be about 7 pounds, or a temperature range of 12° F.

The New York division of the Honolulu Iron Works Company recently made an installation of three large injector type compressors, also known as thermo-compressors, on the first cell of a quintruple effect for Los Mochis cane sugar factory in Mexico. They inform us that they had tests made and found the efficiency to be about as high as possible for this type of compressor. The compressors were supplied with live steam at 100 pounds gauge and each pound of live steam compressed 1.2 pounds of vapor from 3 pounds gauge pressure to 8 pounds gauge pressure thus supplying 2.2 pounds of steam to the calandria. These 2.2 pounds in the calandria would evaporate about 2.2 pounds of vapor so that 1 pound of live steam resulted in the production of 2.2 pounds of vapor which is slightly better than a double effect pre-evaporator.

Centrifugal Separators: Centrifugal separators have come into use again this season. They have done good work in separating liquor from the solids in settlings.

Settlings from ordinary settling tanks, the Petree-Dorr process, or from any other subsider, may be separated in these centrifugals.

They are particularly advantageous in cane sugar factories, where the mixed juice is strained through very fine screens and the fibrous matter removed.

Settlings, devoid of fibrous matter, can only with difficulty be separated in filter presses, on account of their gummy, smeary nature. In centrifugal separators this condition is no hindrance.

The separation in a centrifugal of 40-inch diameter and 24-inch deep takes place at a rate of flow of 25 to 30 gallons per minute, when the speed of the machine gives a centrifugal force of about 500 gravity. It is within safe limits to increase this force to 800

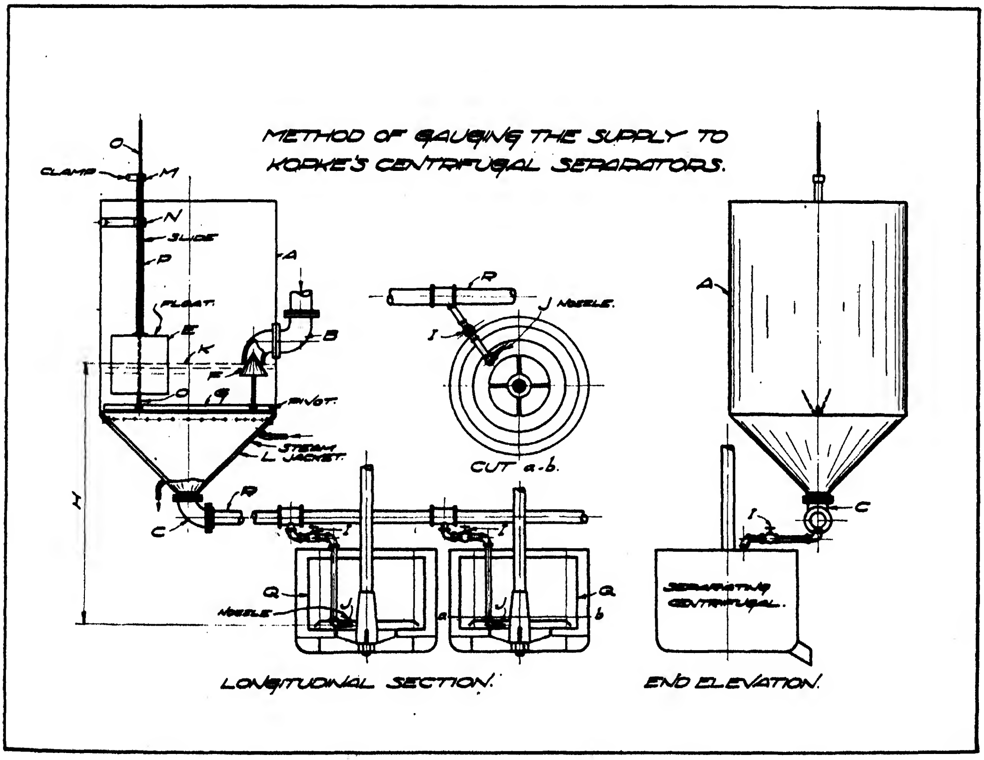


Fig. 3

gravity and by this the capacity of the machine is increased and the clarity of the run-off improved.

With centrifugals separating settlings, the aim has been for a large volume rather than a very clear run-off. The run-off is returned to the unclarified juice.

The construction of the centrifugal separators has undergone some modification since its first introduction some twelve years ago.

The suspended machine with independent electric, or preferably water drive, is now used. The revolving bowl is accurately machined inside and out. The run-off liquor is continuously sampled by having a small stream run over a lighted glass plate.

A very important addition to a centrifugal separating plant is a flow regulating tank. This is illustrated in Fig. 3.

The object of this tank and its fittings is to supply each machine with a constant quantity of unseparated liquor (settlings).

There are two means of regulation. The float may be raised or lowered and fastened in any position thereby increasing or decreasing the hydrostatic head and the flow into the centrifugals. Further regulation can be made by using larger or smaller nozzles "J," discharging directly into each of the revolving machines.

The tank "A" has a conical bottom and is shown here with a steam jacket. It is essential to have the settlings hot for efficient separation. This steam jacket (or steam coil) gives the means to heat the settlings if required before entering the separators.

The accumulated mud cake in the bowl is discharged with an unloader similar in construction to a sugar unloader.

The mud cake is mixed with water to reduce it to any desired sucrose content and is reseparated. The amount of water required is considerably less than is required in filter press work because in mixing the mud, the water comes in intimate contact with every particle of the cake and brings about nearly perfect diffusion, while in a filter press the sweetening-off water or steam is apt to channel through the cake and not come in contact with all sucrose containing particles.

Another factor in favor of centrifugal separation is the comparatively short time required to exhaust the cake of its sucrose. The run-off is quickly returned to the process of manufacture instead of becoming inverted through long exposure.

The saving of heat, sugar from inversion, labor, filter cloth, evaporation through the reduced amount of sweetening-off water, etc., was reported on by Dr. R. S. Norris and appears in the Report of the Committee on Manufacturing Machinery, page 17, in the H. S. P. A. Proceedings of the Forty-first Meeting.

This report itemizes the saving in centrifugal separation over filter press work under the numerals 2, 3, 4 and 5, and are, as far as these items lend themselves, to be expressed in money value as follows:

2. The saving of 75 tons sugar a year (on a 6,600-ton crop) lost by fermentation in filter pressing, say	$ 6,750
3. The saving of $500 a year in filter cloth	500
4. The saving of $600 a year on labor	600
5. Less evaporation on account of smaller amount of water required for washing the mud in the centrifugals than for cake in the presses	Undetermined
Total	$ 7,850

The items 2, 3 and 4 alone show a saving of $7,850 a year on 6,600-ton crop. If one figures the saving on larger crops in the same proportion, one hesitates to accept the figures. For instance, on a 30,000-ton crop over $35,000 would be saved, and Dr. Norris was conservative in his figure.

Old and Modern Settling Tanks as Used in Raw Cane Sugar Factories

In all settlers, whether of the old style 500-gallon rectangular tank with steam pipes in bottom and scum trough on top, or the modern continuous settler, the

aim is to have as complete a separation as possible of the three substances: scum, clear liquor and solids.

The old style clarifier was liming tank, heater and settler combined.

It did good work but on account of loss of heat, large space required and laborious hot work and sloppiness it had to make room for more economical devices.

The modern juice heater was introduced in Hawaii in the early nineties, and settlers of various shapes appeared. Liming, heating and settling are now done in separate apparatus.

Of the many settlers introduced, the Deming was perhaps the best known. Noel Deerr describes it (see Fig. 4) in his book of 1905, page 152, and investiga-

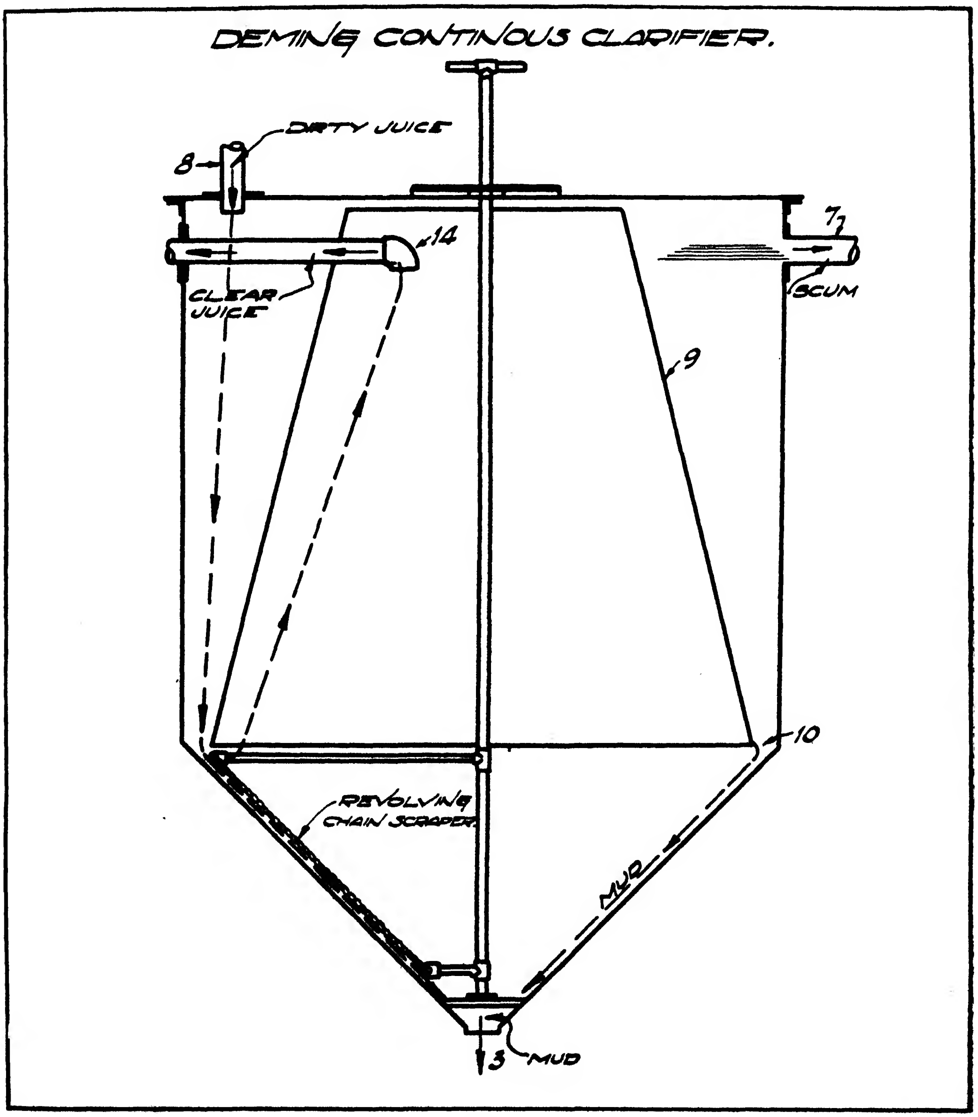


Fig. 4

tion of its work showed it to have been superior to the then existing settlers. Same book, pages 152, 153, has reports by Beeson, Edson, and Geerligs.

Figure 4 shows elements of successfully working settlers of the most modern type.

This design embodies the idea of inducing the lighter impurities wax, gums or scums to rise to the top and flow out in the most direct and undisturbed way. It induces the juice with the heavier impurities to a region low in the tank so that these impurities, by the action of gravity, pass on to the narrow bottom and allow, at a very slow rate of flow, the clear juice to rise to the upper part of the tank where it is drawn off.

The modern settling tank (Fig. 5) has all these principles, but has a number of cones instead of one, thereby multiplying its efficiency and capacity. Cross sections have been proportioned for the most advantageous juice velocities and the concentration of the heavier impurities in the funnel shaped, acute angled bottom.

Figure 5 shows a vertical section of a modern settler for cane juice. It is superior in effectiveness and simplicity to most of the preceding designs.

Its operation is as follows: Dirty juice enters the tank through pipe 8. The scums rise to trap 6 and flow out through pipe 7. From the descending juice the heavy impurities strike baffles 9, travel down on the steep decline and in a concentrated state, through openings 10. The juice travels at a very low velocity up to the discharge pipe 14. The remaining heavier impurities have a chance to settle out before reaching the discharge.

The clear juice finally flows into rending tank 17. The tank is provided with regulating valves from each compartment and delivery pipe for the clear juice.

An important feature of this settling tank is the very steep slope of the cones assuring the downward movement of precipitates. In the lower cones, mechanical means are employed to move and compress the heavier and more concentrated precipitates toward the mud discharge 3.

As indicated in Fig. 5, the mechanism of the revolving parts is compact and simple.

Unstrained Juice Pump

At the second annual meeting of the Association of Hawaiian Sugar Technologists, the use of an unstrained juice pump in Oahu Sugar Company's factory was brought up and mentioned in the report of that session on page 104.

Under the care of the Oahu Sugar Company's engineering staff a new type of valve has been developed in this pump which has worked successfully during the seasons 1923-1924 and is now beyond the experimental stage.

The object of such a pump and the persistency with which it has been brought to working perfection during the last two seasons were prompted by the fact that the juice strainer, as commonly used here and in other cane sugar countries, has some very objectionable features.

Through the intimate mixture of the juice with air (that occurs in the strainer) souring is induced which causes a loss of sugar by inversion, and further, the screenings containing the lowest density and lowest purity liquor

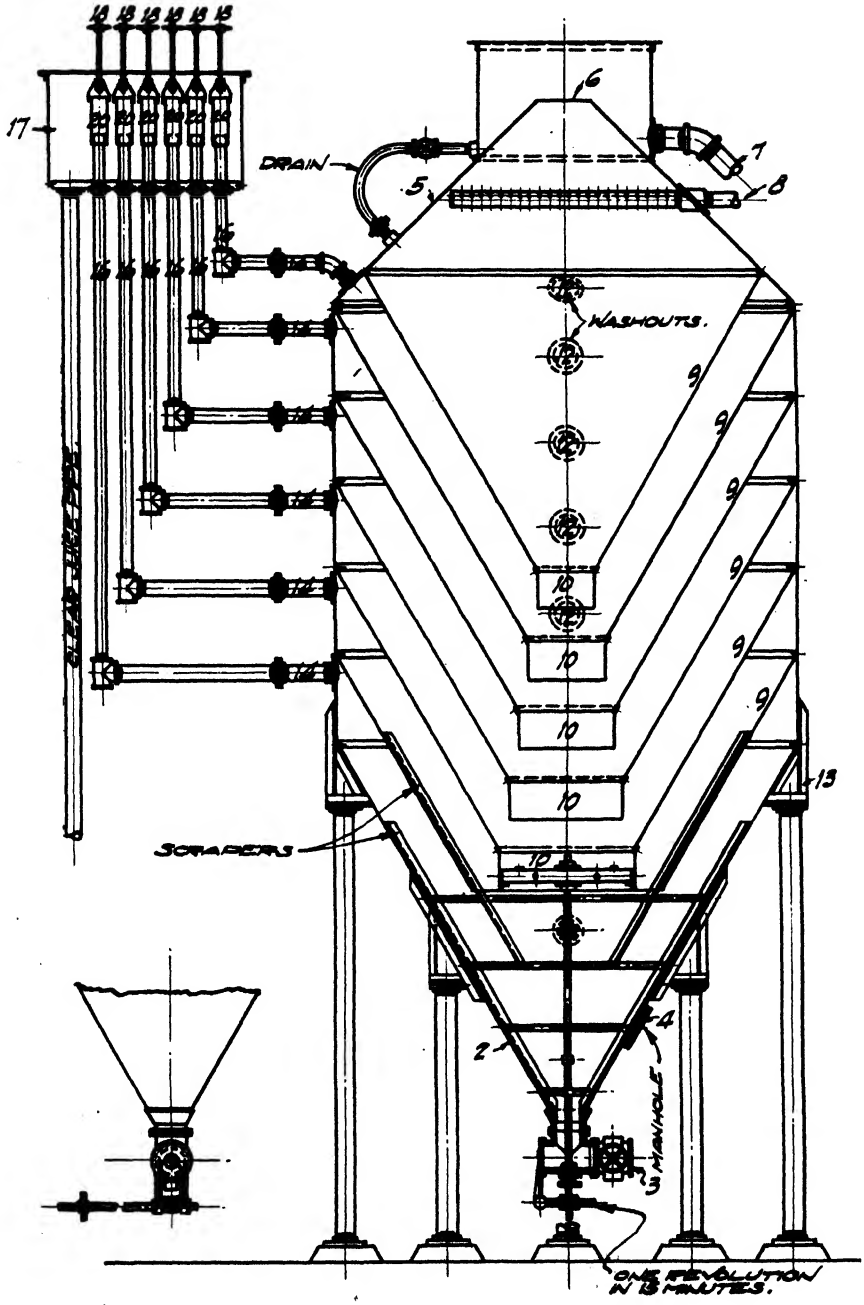


Fig. 5. Ruckstuhls Patented Improved Settler.

are dragged by the slats over the perforated brass screen from the last mill through the discharge of juice of higher density and purity of the preceding mills until it reaches the inflow of the normal juice from crusher and first mill.

The low density and purity juice in the screenings of the last mill is displaced to a large extent by richer and purer juice and this passes through the mills with the bagasse blanket.

By this the rich pure juices are contaminated and the maceration enriched.

These two very objectionable features are, if not entirely, to a large extent eliminated by the use of the unstrained juice pump. W. L. McCleery, of the H. S. P. A., made the following statement at the Sugar Section of the Pan-Pacific Conference:

> In a series of tests on the increase of acidity per 100 density through both tandems at Oahu factory, I found considerably less increase in the mill with the unstrained juice pump than in the other mill equipped with the usual strainer.

Juice Strainer and Mill Juice Tank

Figure 6 shows the cross-section of a juice strainer and mill juice tank designed by E. W. Kopke, of Manila, that is much favored in the Philippine sugar factories.

This design should prove to be useful anywhere, especially where the troublesome jelly-like Leuconostoc forms and causes loss of sucrose and obstructs the flow of juice.

In Fig. 4 is a tank which extends the horizontal length of the strainer and serves the purpose of mill juice tank and supports the super-imposed juice strainer "B."

The strainer is of the slat-scraper type, as commonly used, but has the perforated sheet brass strainer made up in removable sections or panels "C."

The tank "A" is wider than the slat scraper.

By removing the covers "D" any or all strainer panels can be removed and every part of the apparatus becomes accessible.

A person may comfortably enter the tank for cleaning purposes.

Besides the feature of accessibility, the apparatus has a system of steam pipes (not shown) by which the whole apparatus can be thoroughly disinfected.

Lubrication

Lubricating Ball and Washer Bearings of Sugar Centrifugals: This, due to two noticeable reasons, is the source of much trouble in local factories. The first and most important cause for bearing failures of centrifugal driers is due to use of the wrong kind of lubricant. An oil consisting of a medium grade of engine oil, with which there is blended about 15 to 20 per cent acidless or winter strained lard oil has been found to give best results on both types of sugar centrifugal bearings.

In some cases, a medium hard grease is being used as lubricant for the ball bearings. However, unless bearings are completely packed with the grease, and grease does not creep or flow to balls and races, there is simply a groove cut

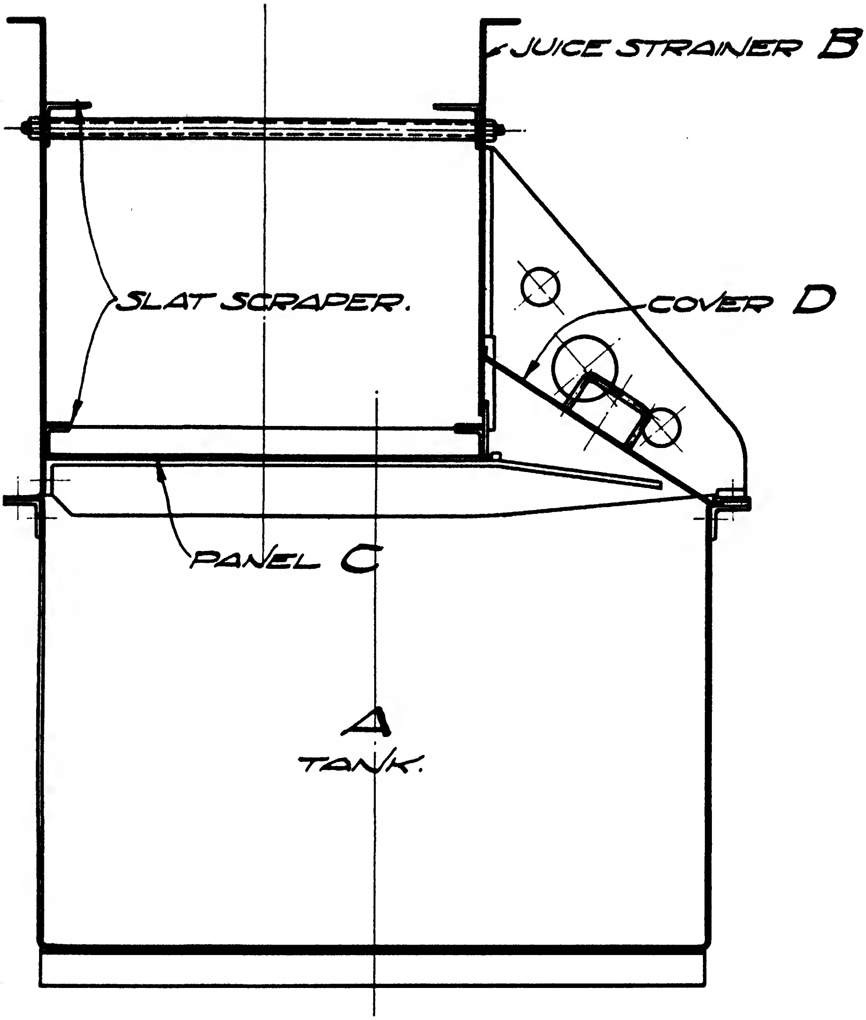


Fig. 6. Cross Section of Juice Strainer and Mill Juice Tank.

through the body of the grease and bearings are soon operating metal to metal, which, it is obvious, will quickly set up a cutting of races and scoring and chipping of balls. When such a condition once develops, there is no lubricant which can lubricate bearings, consequently the destruction of the bearings gradually increases to a point where replacement of balls and races becomes necessary.

Since all ball bearings are surrounded by leak-proof encasements, it is clear that an oil would be eminently more reliable than any solid or semi-solid lubricant.

Reference to the special item of sugar centrifugal lubrication brings to the writer's mind a thought regarding the question of general sugar factory lubrication. Are there not too many different grades of oils being used? This question is asked with the full knowledge that a great many members of our association, have for varying periods regularly used lubricants in sugar factory operation, and are more familiar with the subject than others of us who have accumulated

our opinions in this connection by observing condition of machinery which has either failed or its efficiency unnecessarily impaired by improper lubrication.

Some machinery failures have, no doubt, been due to selection of improper grade of lubricant at time of purchase, or by oilers taking their supply from wrong containers. It is this thought which prompted the query: "Are there not too many different grades of oils being used?"

Would it not be better to use say three grades of oil for sugar factory lubrication? Take for instance a good grade of steam cylinder oil, carrying sufficient compounding to efficiently meet the lubricating requirements in all types of steam cylinders operating at steam pressures between 95 and 125 pounds per square inch. There is sufficient compounding in this type of cylinder oil to give excellent roller-bearing lubrication. It could also be used in worm drives and in all other bearings where it is determined from practice that a heavy oil is required.

Next, a medium grade of so-called high speed engine oil could be successfully used on all types of sleeve and ring oiled bearings. This would include bearings of engines, steam turbines, dynamos, motors, centrifugal pumps, etc. These two grades, with the special oil for sugar centrifugal bearings, could be made to fully meet all lubricating requirements of the average sugar factory and would practically eliminate the possibility of oilers and engine tenders using the wrong oil.

This is simply a thought expressed for the consideration of our members, and while it may appear to many as being somewhat radical, the writer's experience from standpoint of shop observation and shop work, prompts him in submitting it as another step in the direction of safe and economical sugar factory operation.

Supplementary to the foregoing, it might be well to record here the importance of using a good and dependable grade of lubricating oil. By selecting oils of reputable quality rather than because of their cheapness, there will be eliminated many expensive repairs and shut-downs now directly traceable to improper lubrication and improper selection of lubricants.

String Proof Boiling*

By F. D. Bolte

The standard method of boiling low grades string proof in Hawaii is to boil the first molasses over twice, producing three grades of sugar, the second and third sugar being remelted or used as seed for the shipping of sugar and the third molasses discarded as final molasses at about 40 gravity purity.

This has been the system used here at the Hutchinson Sugar Plantation Company for many years, and Table I gives our average purities, etc., for the last five years.

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

For several months I have tried to do this low grade boiling in one stage only and have boiled the second massecuite to about 94 brix, run same into our cooling tanks of 500 cubic feet capacity each, and after about a week pumped three of them to our larger storage tanks and dried this massecuite after about 30 days, giving the results as shown in Table II, viz: a molasses of 42.7 gravity purity which we have discarded as final. We have discontinued using our small coolers and cars with this new system as the massecuite cools off too rapidly in them for this high density work.

We have thus obtained a final molasses of 42.7 gravity purity in 34 days in one boiling, against previously a final molasses of 42.3 gravity purity in 72 days in two boilings. This is a great saving in time, reduces our stock on hand considerably and gives us more centrifugal capacity, as we boil and dry our low grades only once against twice previously.

Complete check analyses of our final molasses from average monthly composite samples made by the H. S. P. A. Experiment Station is, for the years 1923 and 1924, as follows:

Year	1923	1924
Total Solids	73.36	74.10
Gravity and Suspended Solids	82.54	83.06
Sucrose	34.14	35.25
Gravity Purity	41.36	42.44
True Purity	46.54	47.57
Glucose	11.44	11.59
Ash	10.40	10.97
Glucose/Ash Ratio	1.10	1.06

The above low glucose-ash ratio very probably partly accounts for our high molasses purity.

I certainly know that our molasses must be brought to a lower purity to make this one boiling system a success and am now continuing work in this direction.

TABLE I

Old System, Two Boilings

Year	II Massecuite Brix	II Massecuite Purity	II Molasses Brix	II Molasses Purity	Drop	Age Days		
1920	88.0	55.1	84.2	42.0	13.1	15		
1921	88.3	55.5	83.0	42.1	13.4	21		
1922	88.9	52.2	83.9	43.6	8.6	17		
1923	89.3	51.6	86.3	42.4	9.2	22		
1924	90.1	54.8	87.0	43.9	10.9	15		
	III Massecuite		III Molasses				Total Drop	Gravity Purity
1920	92.6	43.0	81.9	31.0	12.0	92	24.1	40.26
1921	92.3	43.5	83.1	32.1	11.4	135	23.4	42.02
1922	91.5	44.0	83.0	35.1	8.9	73	17.1	42.49
1923	93.5	43.8	82.6	35.9	7.9	81	15.7	41.76
1924	94.3	44.7	84.4	37.3	7.4	57	17.5	42.32

TABLE II

New System, One Boiling Only

Date Boiled	Massecuite Brix	Massecuite Purity	Date Dried	Days Old	Molasses Brix	Molasses Purity	Drop	Gravity Purity
July 23	94.1	47.9	Aug. 29	37	85.2	36.6	11.3	42.9
July 26	93.9	51.5	Sept. 2	36	84.0	37.5	14.0	42.5
Aug. 2	94.0	47.6	Sept. 4	33	84.7	36.9	10.7	42.5
Aug. 6	91.7	53.3	Sept. 8	33	83.0	37.1	16.2	42.8
Aug. 9	94.3	52.3	Sept. 11	33	83.0	37.4	14.9	42.8
Aug. 14	94.0	52.5	Sept. 15	32	85.2	37.0	15.5	42.7
Average	93.7	50.8		34	84.2	37.1	13.7	42.7

Boiling House Methods*

By B. B. Henderson

Reports on boiling house methods have been presented to the factory men of these Islands for so many years that it becomes exceedingly difficult to find a new subject to come under this head or even a new approach to an old subject. As a result, reports are now largely a matter of repetitions. However, this does not alter the value of the intention back of these reports, which is, the exchange of information. And as long as results from different factories vary, just that long will the exchange of information be of value.

The boiling house report this year is largely devoted to three subjects, Press Work, Low Grade Work and Commercial Sugar Boiling. Where possible these subjects will be freely supplied with figures showing actual results; the aim being an attempt to arrive at conclusions on a basis of figures rather than opinions. It is hoped that the figures will have a further use as a matter of reference to those who contemplate changes in methods and want to know what might be expected under certain conditions.

Press Work

Pepeekeo Sugar Company: I find that to get a low polarizing press cake, the presses should be tight and the forming of the cake should not be at a greater pressure than 25 pounds. Over three hours washing with water is unnecessary, as a further washing may give a low cake, but a high undetermined loss.

Pioneer Mill Company, Ltd.: Our capacity at this station is much below standard. When grinding 90 tons per hour we have less than three and a half hours available for a complete cycle and less than this when grinding cane from makai fields. I think the reason that we are able to do good work at this station lies in the large amount of cush-cush in the mud and in the fact that the presses are filled at a very low pressure, by gravity, at about 10 pounds pressure. This means that the frames are filled evenly and

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

all parts of the cake are permeable to wash water. It is very rare here to see a cake that is not firm or one that has channeled. The small pressure does not mean that the presses are only partly filled, as they average 1.5 tons of mud per press. As our mixed juice is limed alkaline to phenolphthalein, no extra lime is added to the mud.

Onomea Sugar Company: Presses dressed with double cloths, outside cloth unbleached factory cotton. The advantages are: mud leaves the cloths clean at each emptying, no muddy juice can get to the evaporators and less washing of inner cloths is necessary.

Presses filled by pump, relief valves set at 25 pounds, wash water from second cell of evaporator at 150° F. and 30 pounds pressure. Two presses filling at one time; starting one when other is half full. Washed in one and a half hours. About 2,500 gallons of water per press of 530 square feet area. Press discharges 2,500 pounds of mud. Wash water to below 1° brix.

Average sugar in mud to date .37 per cent. I do not believe the sugar can be washed from the mud with little water. We apply water freely immediately after juice is shut off and endeavor to wash out rapidly. Evaporators ample to handle washings.

The three reports given above are of particular value becuse they represent factories where press work is good. Onomea and Pepeekeo are among the five factories reporting less than 1 per cent polarization in the press cake for the 1923 crop. At Pioneer the polarization was 1.33, but the press station is rated at about 50 per cent of required capacity. A summary of these reports together with certain observations on press work made by the writer are as follows:

Presses must be tight. The water that leaks out between the frames and plates during washing contains very little sugar. This can amount to a surprisingly large quantity of water in some cases. It throws an additional load on the evaporators and adds to the length of time a press must be washed in order to bring the polarization down. In cases where it seems impossible to keep a press from excessive leaking during washing, double pressing has been suggested. Another method of handling excessive wash water leakage would be to separate the leakage from the wash water coming from the cocks and use the former for maceration at the mill.

Pressure during filling should not be greater than 25 pounds. Good press work is seldom accomplished when the pressure exceeds this figure, and a lower pressure frequently gives good results. A gravity head giving from 10 to 15 pounds pressure is a good arrangement. If this produces a soft cake that will channel too easily it can be corrected by heavier liming of the settlings. This cake will probably wash more easily than one made at a higher pressure and not limed so heavily.

Complete cycle of operation should not exceed six hours. Under average manufacturing conditions, where the time is longer than this, inversion is very apt to take place giving a low polarization of the mud and a higher undetermined loss. To guard against inversion the temperature should not fall below 165° F. and the alkalinity not below 7.7 to 8.0 pH.

The quantity of water in washing presses can be reduced by washing with fresh water during the last third of the washing cycle; this flows to a tank from where it can be pumped back through a press during the first two-thirds of the washing cycle.

Low Grade Work

Onomea Sugar Company: Essentials are, ample pan, crystallizers and centrifugal capacities. Good even grain. Struck at 97.0 to 98.0 brix. Moved in crystallizers from 8 to 10 days. Cured without diluting to avoid dissolving sugar, as every per cent dilution of massecuite, the resultant molasses will be increased about one per cent in purity.

This year on account of lack of low grade centrifugal capacity, caused by larger cane tonnage, we have been forced to dilute second massecuite 3 or 4 per cent more than formerly with the corresponding rise in waste molasses purities.

McBryde Sugar Company: Under our conditions, we believe in having a purity of 54-55 and brix of 98-99 for our low grade; also in adding enough water, under close supervision, in the crystallizers to give a brix of 96-97 for drying.

The purity of the final molasses is determined by the brix and purity of the massecuite at time of dropping, skill in pan work, time of boiling, careful crystallizer work and brix of massecuite at time of drying. Any dilutant or heat will raise the purity of the molasses other than molasses or water in crystallizers when skilled attention is given to it.

The purity of the low grade sugar is determined by the purity of the massecuite, quality and size of the grain and brix at drying.

The factors affecting the drying of low grade massecuite, we believe are: size and quality of the grain, brix, purity and temperature of the massecuite when drying and good clarification. Consistent work at the pans is essential for good drying sugar; any attempt to speed up a sugar that is slow drying, due to poor boiling, only results in an increase in the final molasses purity. The brix and purity of the massecuite have to be determined by the available centrifugal capacity, but the massecuite should be as near 70° F., at the time of drying, as possible. Fine suspended matter slows up drying to a marked extent; since the installation of a Peck strainer here, we have noted a great deal of improvement in this respect.

Hawaiian Sugar Company: There is great trouble in getting uniform grain or crystal; the opinions of sugar makers differ as to which is the right way of getting low molasses purity. Many changes are taking place in boiling to finish and we have had very good results here with a purity of molasses of 52 to 54. A higher purity does not answer as well as a 54 purity in boiling even grain. Most of the trouble comes from variety of canes and situation of fields; all troubles are local.

Pepeekeo Sugar Company: The two principal controlling factors of the gravity purity of the final molasses are, the skill in low grade boiling and the glucose content. If a good purity drop in the low grade pan is secured the final molasses will be low, providing the dilution of the massecuite is not more than 95 degrees brix before drying. The average drop at Pepeekeo in the low grade pan is 20 points, which gives a hot molasses of 33 apparent purity. We find that under the same conditions, a molasses of higher glucose content will produce a lower gravity purity than one of a lower content.

At Pepeekeo the purity of low grade sugar and its ease of drying depends on four factors, namely, purity of massecuite, size of grain, clarification and the presence or absence of false grain. A massecuite of 54 purity will dry much better than one of 50 purity and still give a low molasses with a higher purity sugar. A large grain dries better and with proper boiling a good drop can be obtained. Good clarification gives a freer drying massecuite, one that is not too sticky. It is my opinion that the presence of false grain is the main factor in drying of the low grade.

Pioneer Mill Company: In my opinion the factors necessary to reduce the purity of the waste molasses, in order of their importance, are:

1. That the massecuite should be boiled as stiff as it is possible to handle subsequently.

2. That it should be free from grain .1 mm. or less.

3. That the grain should be even and of average size (.3 to .4 mm.).

In low grade massecuite there are two results to be desired: low molasses and higher sugar. While the low grade equipment available is usually the deciding factor on the method of procedure to obtain these results, there are certain other influencing factors the importance of which has not been agreed upon.

The brix purity of the massecuite, and the days in the crystallizers are some of the factors which decidedly influence the purity of the final molasses. Just how much they influence the purity, within certain limits. is difficult to state. A consideration of the analysis of a small number of strikes is apt to be misleading, but if a large number are under consideration, general conclusions might be attempted.

The following figures have been compiled from the laboratory records of the past four years at the Lihue factory to see if such data can throw any light on the subject in question. Over 1,000 strikes are included, representing the analysis of more than 400 samples:

	Massecuite		Molasses		Days in
	Brix	Purity	Brix	Purity	Crystallizers
1921	98.1	51.5	91.7	31.4	11
1922	98.7	52.7	92.6	31.4	13
1923	97.5	51.4	93.6	29.3	11
1924	97.0	53.4	92.8	29.4	12

During 1921 and 1922 the only thing that limited the brix of the massecuite at striking was the difficulty in getting it out of the pan and into the crystallizers. Individual strikes were frequently over 100 brix; time required for discharging the pan was between one and two hours. After about four days in the crystallizers water was added each day until the massecuite was sent to the mixers.

The brix at the time of striking was considerably reduced during the 1923 and 1924 crops. Certain operations in low grade work were facilitated by this change and the final molasses was not higher than it was previously. That it was actually lower is, of course, not attributed to the lower brix but for other reasons that will be discussed later.

From these figures it seems fair to assume that nothing is gained by boiling low grade massecuite to a higher density than it can be handled in the centrifugals. However, the usual factory practice is to boil to a slightly higher brix than can be dried, and water is afterwards added in the crystallizers or a mingler. This is done as a precautionary measure to avoid the possibility of striking at too low a brix, and because if any unforeseen event permits longer time in drying. the benefit of a higher brix will be obtained.

In regard to the final molasses in 1923 and 1924, which was lower than in the two previous years in spite of a lower striking brix, your attention is directed to the figures for 1921 and 1923. During these two years the massecuite stayed in the crystallizers the same number of days, the massecuite purities were practically the same but the purity of the final molasses was lower in the later year. The reason for this is very apparent in the brixes of the molasses, which should be an indication of the drying brix of the massecuite since there was no dilution of the molasses before sampling. That the drying density of the massecuite is

one of the deciding factors on the purity of the final molasses is a fact too well established to need discussion here.

A further study of the Lihue figures in hopes of determining the effect of the massecuite purity on molasses purity seems futile. The figures for 1924 in particular upset preconceived ideas on the subject. One would naturally expect the purity of the molasses to increase as the purity of the massecuite increases, but it did not do so here, even in spite of a lower drying density. A comparison of the four years is quite like comparing one strike with another. It is only necessary to look at the low grade massecuite records of the average factory to see massecuites of the same density, but differing in purity by several points, yet yielding the same final molasses. This leads one to the conclusion that there are other factors of even more importance than the purity of the massecuite that determine the purity of the final molasses.

The following tabulation for the 1924 crop was made in order to see if any effect on the purity of the molasses could be accounted for by the number of days the massecuite stayed in the crystallizers:

Days in Crystallizers	Massecuite Brix	Massecuite Purity	Molasses Brix	Molasses Purity
Under 10	97.0	53.3	93.0	29.3
11 to 15	96.9	53.4	92.5	29.4
Over 15	97.4	53.3	93.6	29.4

As far as the purity of the final molasses is concerned, apparently no advantage is gained in the crystallizers after ten days. Reports based on laboratory separation of the sugar and molasses have shown that there is a continued drop after ten days, but it is so small per unit of time in comparison with the first ten days that in order to get the advantage of it the crystallizer capacity would have to be increased beyond what is practical in manufacture.

The purity of the low grade sugar depends on how completely a separation of the sugar and molasses is accomplished in the centrifugals. In other words, the purity of the remelt depends on the drying qualities of the massecuite. Speaking in terms of *actual factory operations,* what is usually meant when a strike is considered "good" is that it can be dried and the better it dries the higher the melt.

It is now generally agreed upon that grain less than .1 mm. long is one of the chief causes of difficulties in drying low grades. Opinions differ as to whether irregular grain longer than .1 mm. can cause poor drying, but as a rule an even grain seems to be desired. If "even" grain is intended to mean that all grain is of the same length then the writer does not believe that, as far as grain is concerned, an even grain is essential. Strikes containing grain all of .2 mm. in length will not dry as easily as strikes of irregular grain ranging from .2 mm. upward; the range being limited to that length which is usually found in low grade strikes.

There is no doubt that the grain is a contributing factor to the drying qualities of low grade, but, it is not the only factor; otherwise, the difficulties in drying could be overcome in the pan work. Rather than blame the drying on the grain it seems possible that the grain might be an indication of either of two things or of them both. First, it might indicate the presence of constituents in the

molasses which are causing the trouble. Second, the grain might indicate how successfully the pan work has been done in spite of these constituents.

Obviously, entirely too much poor work in sugar factories is blamed on the juice or the cane or various other causes, but it seems evident that the juice on different plantations does work differently. A. Fries reported to this Association in 1920 that he noticed a very marked difference in results between Lahaina and Makaweli. He said:

> In respect to the crystallizer strikes, I have noticed a very important difference in the massecuite here at Makaweli and that at Lahaina. Although boiled under the same conditions and of syrup of similar purity, the massecuite is, on the whole, far freer and less viscous than that at Lahaina. We are able to purge the low grades in less time, getting a higher purity melt and a final molasses from two to three points lower in purity. Others have observed that while it is possible to do very good work in one factory, the same sugar boiler will find it impossible to get equal results at some other factory, though the equipment and conditions are alike. This is due to the peculiar quality of the juices. Probably the nature of the impurities if better understood would give a more satisfactory explanation.

The writer has had a similar experience in comparing Lihue with several other places, but particularly with Lahaina. On my arrival at Lihue certain changes were made in the boiling house to accommodate the accumulation of low grade sugar that would result from Sunday drying, it being anticipated that this sugar would be loaded with molasses and could be best kept on a concrete floor with retaining walls to keep it from spreading. The results were quite to the contrary. The low grade dried so thoroughly that it could be kept in bags without much discoloration of the bags. After certain changes in methods were inaugurated to conform with usual practices the purity of the final molasses was very much reduced. Evidently some constituents or qualities of the juice are responsible for the ease with which the low grades work.

Pan men attribute difficulties in boiling low grade to the molasses being "sticky." The same reason is given for difficulties in drying, when the grain is not at fault. The effect of viscosity may not be noticeable on plantations where conditions regarding elevation, variety, time elapsing between harvesting and grinding and other conditions are fairly constant, but, on plantations where extremes are met, difference in viscosity and resultant difficulties in low grade work are noted.

High viscosity is particularly noticeable in molasses from cane that is ground a long time after burning, as might result from an accidental cane fire. It differs with different varieties, elevations and soil conditions. It is not dependent on purity, meaning that a cane giving a high purity juice will not necessarily give a molasses of low viscosity and a 50 purity molasses is not always more viscous than a 55 purity. As far as Lihue is concerned, viscosity and its resulting difficulties in working low grades does not depend on clarification. Here the turbidity of the clarified juice on 3-hour composite samples for the last three months of the year averaged 1.7 cm. and yet the low grades work easily and the results are satisfactory.

Reference has been made to the literature on sugar that is accessible to the writer on the subject of viscosity. Geerligs says: "It is therefore desirable from a manufacturer's point of view that the molasses be as little viscous as possible in order to enable it to be easily separated from the crystals without much washing in the centrifugals."

Deerr: ". . . . . accordingly viscosity can only be of influence in determining the time taken for complete crystallization. Technically this influence is not unimportant, and is particularly noticeable in the comparison of the rapidity of crystallization in refineries and in raw sugar houses, material of equal purities (but without the 'gums' removed by char filtration) crystallizing much more rapidly in the refinery than in the raw sugar house."

Claassen: "The viscosity of syrups or molasses is decidedy a hindrance to rapid graining."

It is observed that these writers agree that viscosity has an objectionable effect on boiling and drying. The causes of viscosity are thoroughly discussed by Geerligs, but they are irrelevant at this time, it being more to the point to initiate a study of effects based on actual viscosity determinations. To date it has seemed impossible to get a means of successfully measuring the viscosity of undiluted high density sugar house products. The writer attempted this a few years ago by means of timing the fall of a steel ball through a column of molasses. Concordant results could not be obtained. It is understood that the H. S. P. A. Experiment Station has now developed a viscosimeter. When the viscosity of the molasses is accurately determined it is highly probable that it will give considerable light on difficulties encountered in low grade work.

In the consideration of low grade the writer feels that it resolves itself into the understanding of certain fundamental facts, the application of which is limited by equipment available under manufacturing conditions.

In order to extract the sugar that is in the molasses, crystallization is resorted to. The greater the surface of the crystals exposed to the sugar solution the greater will be the opportunity for the sugar to crystallize out of solution. The smaller the crystals per given weight the greater will be the surface, but as the size of the crystals decreases the difficulties in drying increase. Hence the limiting factor here is the centrifugal capacity.

The lower the water content of the massecuite the more sugar has crystallized out. Crystallization increases with density, but the difficulties in drying also increase with density, making the centrifugal again the limiting factor.

The lower the purity of the material in the pan the greater will be the difficulty in getting grain and making it grow. The longer the time for this operation the greater will be the opportunity of getting the desired results. Consequently, the limiting factors here are purity, pan capacity and skill.

Crystallization in the pan is accomplished by the reduction of water, and in the crystallizers by the reduction of temperature. It would then seem that when all other conditions remain the same, the amount of crystallization that can take place in the crystallizer is limited, but it is not limited in the pan.

The purity of the remelt indicates how completely the drying has been accomplished and how much of the waste molasses is taken back into process. The

available centrifugal capacity determined this and the practical limit to the molasses taken back will depend on the capacity for handling both low and high grade products.

The non-sugars present in low grades add to the difficulties in crystallization and separation. It is possible that their effect can be measured in terms of viscosity. Investigation along this line should be inaugurated.

Commercial Sugar Boiling

Letters sent out requesting data to come under this head asked for information relative to the advantages or disadvantages of the Pioneer system of sugar boiling in comparison with other systems. The impression conveyed by the replies is that the number of factories that are changing over to the Pioneer system is increasing and satisfactory results are following.

The demand for a high polarizing sugar is one of the reasons for the increasing popularity of the Pioneer system. It is doubtful if any factory attempts to get a high commercial sugar and a molasses low enough for low grade by maintaining all the high strikes at a fixed purity. Those not using the Pioneer system evidently do boil commercial sugar strikes of different purities, but not by returning all or none of the molasses as is usually done in the Pioneer system.

This brings up the fact that there is one variation to this system that sometimes comes up for discussion. The Pioneer system can be briefly described as the system of taking back *all* of the molasses from the preceding strike until the molasses has reached a purity low enough for the crystallizer strikes. Starting with a syrup purity of 84, the B molasses will be between 50 and 55. If 55 has been set as the arbitrary limit for crystallizer strikes what should be done if the B molasses is 56? If all of the B molasses is taken back into a C strike, the resulting massecuite will be below 70; if only half is taken back the C massecuite will have a purity higher than the B massecuite. An answer to the question depends to a great extent on capacities. If there is ample pan and centrifugal capacity a C strike should be made. Where these capacities are limited and there are enough molasses tanks to reserve some exclusively for B molasses, it will be easier to boil the C strike to a fixed purity, using only a part of the B molasses, necessitating that the remainder be held over for some future strike.

However, it must be remembered that if the latter procedure is followed it introduces certain complications into the control of the boiling, which the Pioneer system aims to avoid. The simplicity of control in a boiling system should not be underestimated, particularly in a factory lacking in adequate supervision, as may be the case in smaller factories during the night shift. With the Pioneer system, a brief examination of the pan records or an inspection of the pan floor will immediately tell if the boiling instructions have been and are being correctly carried out. This is but one of the advantages in strictly adhering to the Pioneer method. Where capacities permit, all or none of the molasses should be returned to the high grade strikes.

Hutchinson Sugar Plantation Company: We have been using the Pioneer system here for the last 14 weeks and find it a great improvement over our old method of returning molasses to all our No. 1 strikes without any given definite system or routine. The enclosed table of averages purities and polarization will give the best information available. We certainly shall continue using the Pioneer system here in the future:

	A			B			C		
	MC.	Mol.	Sug.	MC.	Mol.	Sug.	MC.	Mol.	Sug.
May	80.4	61.8	97.6	75.9	56.7	97.1	73.1	54.1	96.9
June	83.3	64.2	97.9	77.5	57.7	97.0	72.9	53.6	96.8
July	79.3	60.1	97.5	76.0	56.1	97.3	72.2	53.6	97.1

Onomea Sugar Company: We changed to the Pioneer system at the beginning of 1921. Previously we endeavored to make uniform strikes of 78 to 80 purity, giving sugar of 96.0 to 96.5, polarization and molasses of 50 to 55 purity, starting every week with fresh molasses. This meant extensive reboiling of molasses. The demand of the refineries for a higher polarizing sugar than we were then able to make and the desire to keep our molasses purity down, caused us to adopt the above method, which is still in use at this factory.

Some of the advantages are, a higher polarizing sugar without increasing the purity of the molasses for crystallizer strikes, no repeated boiling of molasses and only one strike of molasses on hand at one time.

Average to date:

	Massecuite Purity	Molasses Purity	Sugar Pol.
A	85.5	67.1	98.42
B	78.5	57.1	97.08
C	75.0	52.0	96.63
Average polarization to date of all strikes			97.48

McBryde Sugar Company: We believe the Pioneer system of sugar boiling to be a very satisfactory method on account of its flexibility and systematic elimination of molasses, resulting in a better color and filtrability of No. 1 sugar and easier working low grade. The drop in purity from massecuite to molasses in our high grade strikes is from 20 to 24 points.

Hamakua Mill Company: I use the one-six method, that is, one straight syrup strike to five mixed strikes. Below is a tabulation of one week's pan work consisting of 39 strikes of commercial sugar, 6½ cycles of 6 strikes each, average purity 76.60, molasses purity 53.58. Out of these 6 cycles, I boiled 9 No. 2 strikes averaging 49.45 purity.

	Purity Massecuite	Purity Molasses	Points Drop
A	86.78	68.77	18.01
B	78.35	54.27	24.08
C	76.85	50.38	26.47
D	74.58	50.15	24.43
E	74.12	49.98	24.14
F	73.18	49.53	23.65

I know of no reason why we should have a large drop this year over last year except for the Petree Process. We have a cleaner syrup, otherwise our juices have been practically the same. The massecuite is dried hot.

Waimanalo Sugar Company: In using the Pioneer system I boil a D strike if the C molasses is over 54 purity, otherwise the C molasses is boiled for crystallizers.

Average for two weeks:

	Sugar Polarization	Massecuite Purity	Molasses Purity	No. of Strikes
A				
Range	97.1–98.4	82.2–86.5	61.5–68.5	9
Average	97.7	84.0	64.8	
B				
Range	96.5–97.2	73.2–78.3	50.8–57.4	9
Average	96.7	75.0	53.8	
C				
Range	96.6–96.7	72.7–74.9	51.3–54.6	4
Average	96.1	74.0	53.0	
D				
Average	95.2	73.3	50.0	1

Hawaiian Sugar Company: The boiling at the Hawaiian Sugar Company's factory consists usually of four strikes of about 38 tons of sugar per strike. The procedure we follow is to start a strike of 3 tons of seed of about 82 purity and after the pan is filled up with syrup to cut half over into another pan. The strike is completed with syrup of 87 purity and gives a 97.5 sugar with .5 per cent moisture and 72 purity molasses. The next strike is made from the other half of the cut and the molasses from the first strike. This will give a 97 sugar with .6 per cent moisture and a molasses between 62 and 64 purity.

The seed pan is again started up in the manner previously described and the first cut is finished with the molasses from the second strike. The resulting molasses is 58 purity and the sugar 97.0 polarization. The other half of the cut is finished with 58 molasses and gives a 96.8 sugar and a molasses of between 52 and 54 purity. This molasses is boiled for crystallizer strikes.

Pepeekeo Sugar Company: We are making a 97.5 polarization sugar by boiling a straight syrup strike every third pan. This massecuite has an 86 purity, giving a 98.3 sugar and 60 to 62 purity molasses. This is all returned, resulting in a massecuite of 77 purity, a sugar of 97 polarization and a molasses of 51 to 54 purity, of which a part is used in the third strike which gives a massecuite of 75, a 97.3 sugar and a molasses of 50 to 52 purity, all of which is used in boiling the low grade. As high a polarization sugar is made as the capacity of the low grade pan and machines will permit, without excessive sucrose loss in the final molasses.

Pioneer Mill Company: The Pioneer system has been used here for many years. Its chief advantages are in its flexibility and in the "cleaning the house" of molasses every third strike. Its chief disadvantages are that it requires three sets of molasses tanks, each holding the molasses from one strike or more, and that the mixer be completely emptied between strikes. Neither of these, however, will apply here, as we have eight molasses storage tanks on the pan floor and three more on the ground floor and our mixer is too small to hold more than one strike. We have storage capacity for 1,184 cubic feet of "A," 1,239 cubic feet of "B," 1,421 cubic feet of "C" molasses, besides 410 cubic feet below the centrifugals. In 1923, the molasses from the different grades averaged 35 tons for "A," 38 tons for "B" and 40 tons for "C."

The flexibility of this system was very evident this season when we desired to raise the polarization of our shipping sugar. Last crop, our sugar polarized 97.37 at the refinery. So far we have received returns on 26,000 tons which have polarized 98.22 at the refinery (including sweepings, etc.). This gain of .85 was very simply accomplished by using a little more water at the centrifugals. The effect of this on the method of boiling was as follows: The amount of seed was reduced by one-third to counteract the effect of the wash water and to reduce the "total small" grain. The drop in purity from massecuite to molasses was reduced by 1 per cent, which increased the number of "C" strikes. In 1923, we boiled 68.56 "C" strikes per 100 "B" strikes, while in 1924 there were

89.54 "C" per 100 "B" strikes. Part of this increase, however, was due to the higher syrup purity, with the consequently higher purity of the "A" strikes and to the manufacture of considerably more "store sugar." The average time of drying all three grades of sugar was reduced by almost half an hour. The following tables show the apparent purity (dry lead method) of the massecuite and molasses, the percentage of the three grades and the composition of the strikes. Strikes of store sugar are included with the "A" strikes:

	Syrup Purity	Massecuite A	Massecuite B	Massecuite C	Massecuite D	Molasses A	Molasses B	Molasses C	Molasses D
1922	85.49	84.3	76.9	73.9	73.5	65.9	58.4	55.6	55.3
1923	86.16	85.2	77.2	74.4	70.6	65.3	56.1	53.4	50.5
1924	86.87	85.76	78.7	74.4	....	67.4	58.4	54.6	....

	Number of Strikes A	Number of Strikes B	Number of Strikes C	Number of Strikes D	Per Cent A	Per Cent B	Per Cent C	Per Cent D
1923	336	334	229	1	37.3	37.1	25.5	0.1
1924	393	392	351	0	34.6	34.5	30.9	0.0

AVERAGE COMPOSITION OF STRIKES

("Tons" by measurement)

	1923 Syrup	1923 Remelt	1923 Molas.	1923 Seed.	1923 Mass.	1924 Syrup	1924 Remelt	1924 Molas.	1924 Seed.	1924 Mass.
First cut	47.2	....	....	6.56	....	48.0	....	....	4.33	....
Second cut	6.5	....	....	....	21.8	7.1	....	....	....	21.4
"A"	50.7	11.4	....	....	23.9	47.9	13.3	....	....	24.3
"B"	16.6	4.2	34.9	....	23.6	19.9	3.8	35.2	....	23.8
"C"	15.6	4.4	34.4	....	23.9	19.9	4.1	35.8	....	23.7

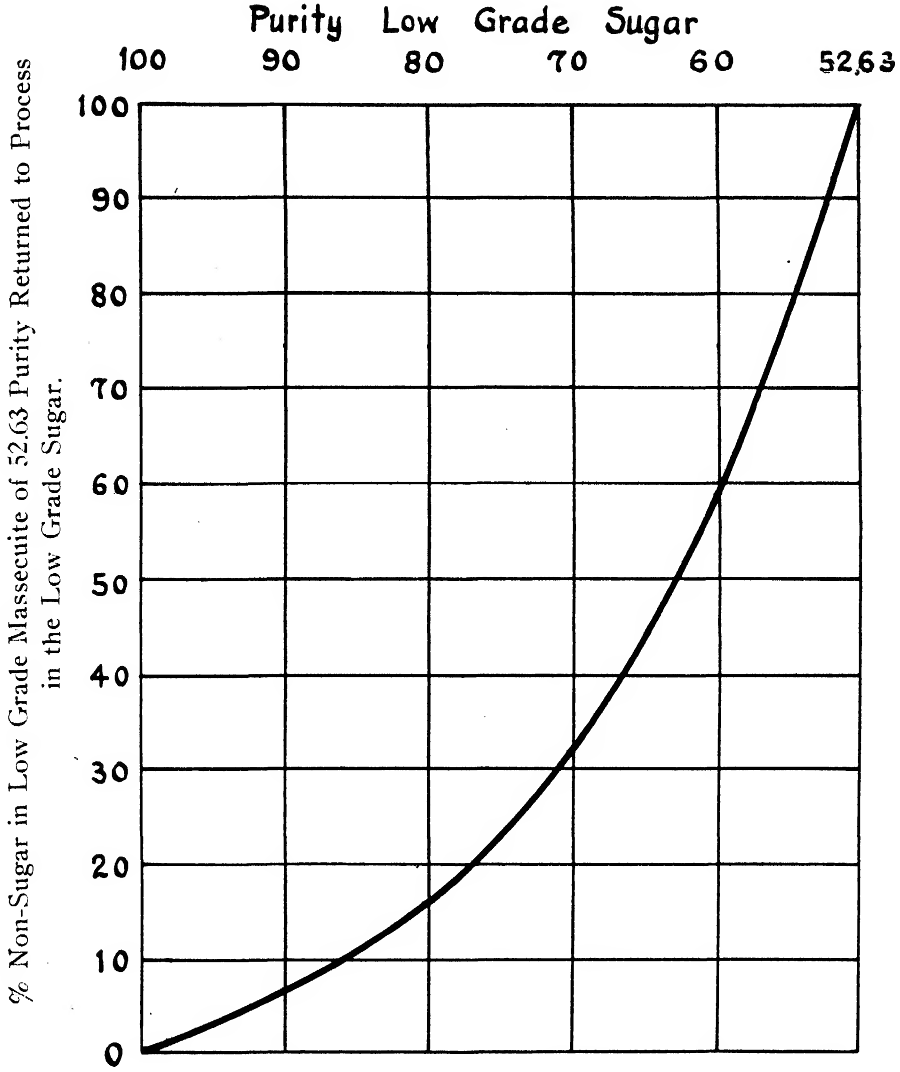
	Per cent Strikes Containing Remelt A	Per cent Strikes Containing Remelt B	Per cent Strikes Containing Remelt C	Average Cu. Ft. Remelt Used A	Average Cu. Ft. Remelt Used B	Average Cu. Ft. Remelt Used C
1923	84.36	72.24	70.22	12.14	5.77	6.25
1924	95.40	77.81	82.39	13.96	4.84	4.94

MISCELLANEOUS

Double Purging: One of the aims in the recent changes in boiling in the Islands is to limit reboiling. With the Pioneer system the only possibility of extensive reboiling is the return to the process of molasses with the low grade sugar. Any other product that is returned, is a *solution* of sugar, but in the case of low grade sugar it is a *mixture* of sugar crystals and waste molasses.

In order to calculate the quantity of material that is returned, a low grade massecuite of 52.63 purity was assumed to be a mixture of 25.25 parts of sugar crystals of 100 per cent sucrose and 74.75 parts of waste molasses of 35.48 gravity purity. It will be noted in the accompanying graph that the quantity of waste molasses returned to the process is approximately inversely proportional to the purity of the low grade sugar.

An 80 purity low grade sugar is probably above the average of low grade purities reported this year, and yet it means that 16 per cent of the *waste molasses* is returned to the commercial sugar strikes. When the purity is 70, the molasses



returned is 32 per cent, which, in the case of Lihue, would be equivalent to saying that every fifth crystallizer strike is due to returned waste molasses.

Walter E. Smith, in his work on the filtrability of raw sugar, concludes that filtration difficulties are due principally to finely divided non-settling matter. On a special investigation trip to Kauai he found that Lihue was making a raw sugar of high filtration rate from syrup of low filtration rate. This was contrary to what he had found at other factories and he attributes this condition at Lihue to be due to the comparatively low quantity of waste molasses that is returned to the process with the low grade sugar. This is compatible with his former findings that low filtrability is due to non-settling matter and as he points out the "molasses represents the greatest concentration of this non-settling matter."

At the suggestion of Mr. Smith some of the factories have started double purging of the low grades in order to get a higher remelt. The scheme consists of making a magma of low grade sugar with water. This magma is then dried, giving a remelt considerably higher than the original low grade sugar and a molasses that is about the right purity to be boiled for crystallizer strike. It is to be noted that the waste molasses is kept out of the commercial sugar strikes, which should attribute to a higher filtration rate of the raw sugar, but it is returned to the crystallizer strikes as formerly.

The writer has not been able to get much data covering actual results of double purging or information on the changes and extra equipment necessary. Toward the end of the present crop Waimanalo double purged the low grade and it is understood that from a low grade magma of 72 to 75 purity they were able to obtain a double purged sugar of from 85 to 87 purity and a run of between 48 and 50 purity. Later the magma was reduced to 68 to 73 purity, which on the second purging gave an 86 to 90 purity low grade sugar and a run of between 46 and 50 purity.

Liming: Equipment that will permit an easy means of keeping the limed juice at a uniform reaction, is the exception rather than the rule in our sugar factories. The most common arrangement is to dump the raw juice from the scales into a large receiving tank where milk of lime is added at the same time as the juice. Mechanical stirrers of compressed air are used to attempt a good mixture, the reaction being regulated by testing the limed juice from a sample pipe that is tapped into the pipe line leading to the heaters.

The arrangement is usually not satisfactory. It is difficult to get a good mixture of a few buckets of lime milk with one to two thousand gallons of juice, especially when the limed juice is constantly being drawn off. The Waipahu liming device has expedited the problem by introducing a constant small stream of milk of lime into the raw juice just before it enters the limed juice pump. The Makee Sugar Company handles it in a satisfactory manner by weighing on a small scale enough slaked lime for one scale tank of juice. Water is added to this lime to make a milk which is put into the scale tank before the juice is turned in. Compressed air blown up in the receiving tank under the scales further assures a good mixture.

Both of these methods give good results when only mill juice goes into the receiving tank, but when the press juice has a different reaction to the clarified juice it must also go into the receiving tank. Under actual working conditions this means that just before a scale tank is dumped the juice that is being drawn from the receiving tank is press juice, resulting in an uneven reaction of the juice going to the heaters. The writer understands that at Wailuku a small tank to hold the press juice has been installed alongside of the juice scales. The press juice is allowed to accumulate in this tank and it is emptied into the receiving tank when every scale tank is dumped.

Lihue has solved the problem by welding a small cylindrical tank to the pipe that leads from the receiving tank to the intake of the juice pump. The tank is made from a section of a 10-inch pipe and is open at the top. The press juice is pumped into the tank and joins with the limed juice at a constant rate.

This has made it possible to carry a more uniform reaction in the limed juice. The writer believes that where there is sufficient gravity head from the presses to this pump the tank can be dispensed with. All that will be necessary will be a pipe line from the presses joining the limed juice line near the intake of the juice pump.

In conclusion, the writer wishes to acknowledge the receipt of data relative to this report from G. F. Murray, Hamakua Mill Company; J. H. Pratt, Pioneer Mill Company; Wm. Schneider, Waimanalo Sugar Company; A. B. Melancon, McBryde Sugar Company, Limited; H. D. Beveridge, Onomea Sugar Company; F. D. Bolte, Hutchinson Sugar Plantation Company; Wm. Ebeling, Hawaiian Sugar Company; Norman King, Koloa Sugar Company, and the Sugar Technologists of the H. S. P. A. Experiment Station.

Centrifugal Pumps*

By Wm. H. Getz

Rotary or wheel pumps are among the earliest types of pumping machinery known. They were operated by hand or by slow moving animals, or perhaps, by the current of a stream or river and, consequently, their speed of rotation was very low. No attempt, therefore, could be made to utilize the centrifugal effect of this rotation and in the primitive forms they served merely as lifting devices for buckets or troughs, the elevation to which the water could be raised being limited by the height of the wheel. These earlier forms cannot, therefore, be classified as centrifugal pumps, although they possibly suggested the use of this type.

On first acquaintance a centrifugal pump seems to be rather erratic in its performance. It does not appear to follow any particular laws, and in many cases its action is exactly contrary to the well known laws governing other types of pumps. Size and capacity seem only remotely related. A 10″ pump may deliver two million gallons or six million, or we may find small pumps with capacities much greater than big ones.

In cases where a definite amount of water is to be pumped, we note that the higher the head the smaller the pump required. Also, we find that when we lower the head on a centrifugal pump in operation, we increase the power needed to drive it. Then again, there seems to be little, if any, connection between the size of the pump and the size of the suction and discharge piping.

Paradoxical as these facts seem to be, they are, however, easily understood when we know the laws governing this type of pump which are just as definite as those relating to any other type of machinery. The centrifugal pump is a machine which depends primarily for its operation on the development of velocity.

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* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

It is governed by two simple laws—first, that the head varies as the square of the speed, and second, that the capacity varies directly as the speed. The velocity of the water leaving an impeller is approximately the same as the velocity of the rim of the impeller, and must be about eight times the square root of the head pumped against, or about equal to the velocity that water would attain in falling from the height to which it is being raised.

Theoretically, a centrifugal pump imparts a sufficiently high velocity to a liquid to carry it to the necessary height. In reality, a transformation from velocity to pressure takes place in the pump so that the liquid in leaving has a velocity only sufficient to carry the desired quantity of water through the discharge line. Should the discharge valve be closed, all the velocity will be converted into pressure.

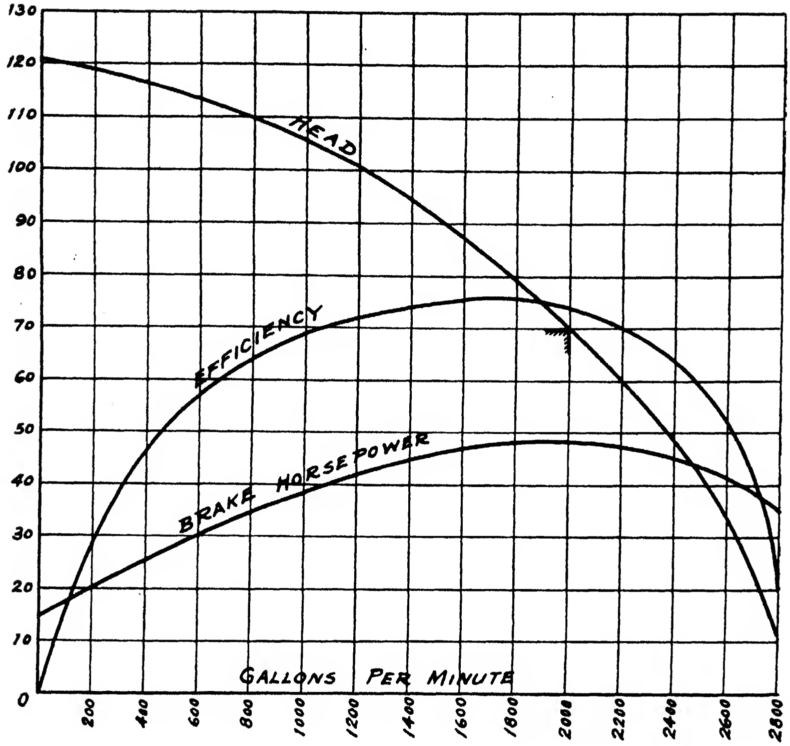
The peripheral velocity of the impeller of a centrifugal pump has, therefore, a very definite relation to the head against which the pump must operate. High heads or pressures of necessity mean high peripheral speeds in order that the velocity attained by the water in the pump may be sufficient to produce the necessary kinetic and pressure heads. High peripheral velocity can be produced either by a large diameter runner operating at slow speed or a small impeller operating at high speed.

Previous to the development of the steam turbine, centrifugal pumps for high head were almost necessarily motor driven, as the only prime mover available for driving them was the slow speed steam engine, which required impellers of such large diameter that they were difficult to manufacture, especially for small capacities. Large sizes also greatly increased the weight, thus tending to offset two of the big advantages of this type, namely, low cost and small space occupied. With the introduction of the steam turbine, operated at extremely high speeds the problem of direct connection to centrifugal pumps was reversed, it being now necessary, except for very high heads, to use reducing gears to bring the speed within the limits of pump design. The lower limits for the diameter of a centrifugal pump impeller are fixed by the fact that it must be enough larger than the suction inlet or eye to provide the necessary space for the vanes.

A very large percentage of the centrifugal pumps which are installed is motor-driven, and fortunately, the range of speeds obtainable is very well suited to most conditions. However, since no economical method of speed variation is available, it is desirable that the pump specifications be as near to the actual operating conditions as possible.

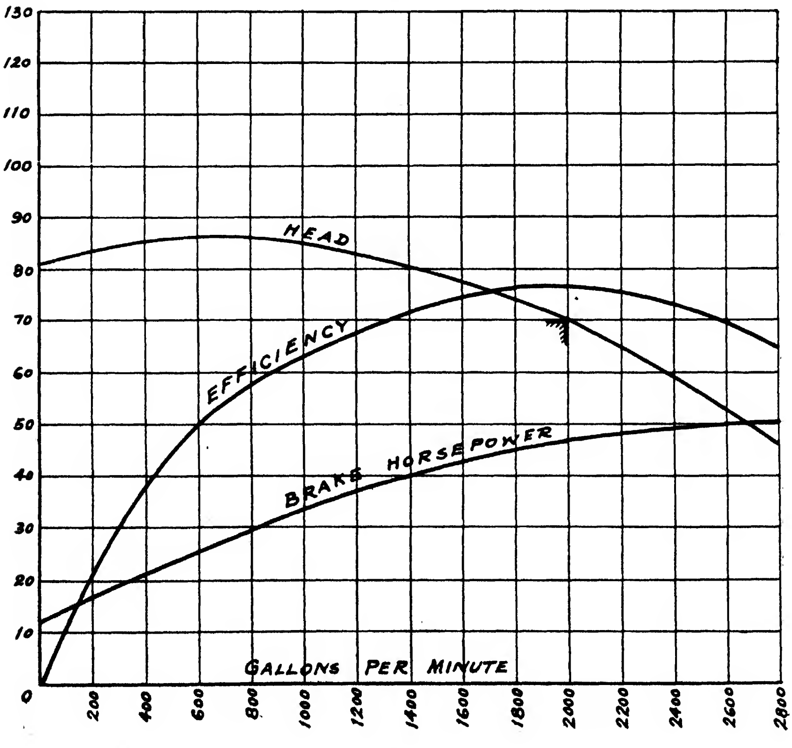
Although a centrifugal pump once built and installed has only small flexibility unless speed variations are possible, there is, however, quite a little latitude in design possible, so that the pump may be adapted to take unavoidable fluctuations to the best advantage.

Varying the blade angles of the impeller causes a considerable change in the characteristic curves. The most advanced builders provide as many as four distinct types of runner, from which the one best suited to conditions in each case may be selected. We are giving three charts illustrating this feature. In each case the pump is designed for the same normal conditions, namely, 2,000 g. p. m. against 70-foot head.



HEAD
EFFICIENCY
BRAKE HORSEPOWER
GALLONS PER MINUTE
0
10
20
30
40
50
60
70
80
90
100
110
120
130
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

Fig. 1



HEAD
EFFICIENCY
BRAKE HORSEPOWER
GALLONS PER MINUTE
0
10
20
30
40
50
60
70
80
90
100
110
120
130
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

Fig. 2

Fig. 1 shows a pump having a very steep head-capacity curve. Large changes in head produce relatively small changes in capacity. This type would be suitable for use with a barometric condenser where the head is greatly reduced after the vacuum has been produced. The horse power curve is of the falling type, being a maximum under normal conditions.

Fig. 2 shows a pump having a very flat characteristic curve. This pump would be well adapted to maintaining a nearly constant pressure in a city's water mains, when the demand varies greatly. The low shut-off pressure would also serve as a protection against high pressures in the pipes at very low capacities. The horse power curve in this case is of the rising type. It is evident that had the normal rating of this pump been, say, 1,400 gallons per minute against 80-foot head, the maximum horse power required would be more than 25 per cent above that required for rated conditions.

For ordinary uses runners are usually furnished with characteristics between the extremes shown above, as illustrated in Fig. 3.

Since it is evident that the design of the impeller affects the horse power required under other than normal conditions, the motor furnished with a pump should in all cases be large enough to care for any possible conditions of operation. For this reason a falling horse power curve is desirable to limit the excess motor horse power required to take care of these unusual conditions. The best form of horse power curve is one which is a maximum for normal conditions and falls for either higher or lower heads. A centrifugal pump usually requires 40 per cent or less of normal power when the capacity is zero, and for this reason it is advisable to start the pump with the discharge valve closed. When this is not practicable, large motors should be of the wound rotor type.

As an illustration of the thoroughness with which some manufacturers have studied their product to permit of predicting with great accuracy the performance of a pump prior to its actual test, we are reproducing in Fig. 4 a so-called oak tree curve, showing the characteristics of a 10″ type "S" pump running at 1,160 r. p. m. These curves are made from actual tests as follows: The pump is first fitted with a maximum sized runner, in this case 17¼″ diameter, and a series of tests is run at different heads, giving the data for the upper curve. For each test, the efficiency is noted on the curve. The runner is now turned down to a somewhat smaller diameter and new tests run giving the data for the next curve. This is continued until the runner has been reduced to a minimum size. Points of equal efficiency in the different test curves are now connected giving the peculiar appearance from which these curves derive their name. This operation must then be repeated to obtain similar curves for all other standard speeds.

Practically, these curves are of value as follows: Suppose it is desired to know the performance of this particular pump for a capacity of 3,000 gallons per minute against a head of 90 feet. Taking the intersection of these two values, we find that the efficiency would be at least 80 per cent. A curve drawn through this intersection parallel to the adjacent curves, gives the characteristic "head-capacity" curve for the pump. Using the efficiencies shown for a number of points will give the Brake Horsepower curve, and we now have complete characteristic curves for this pump when designed for the normal conditions assumed

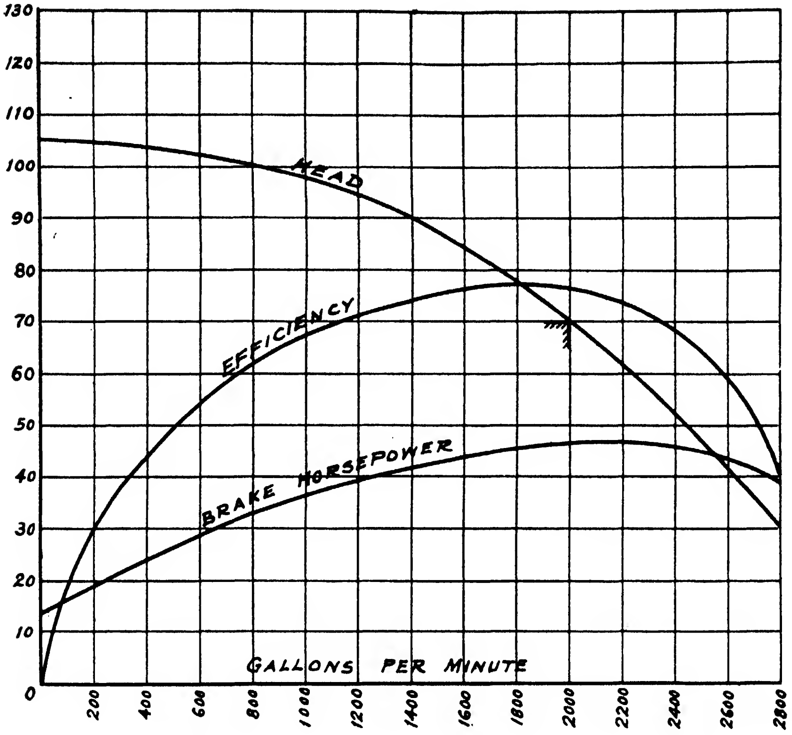

HEAD
EFFICIENCY
BRAKE HORSEPOWER
GALLONS PER MINUTE
130
120
110
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

Fig. 3

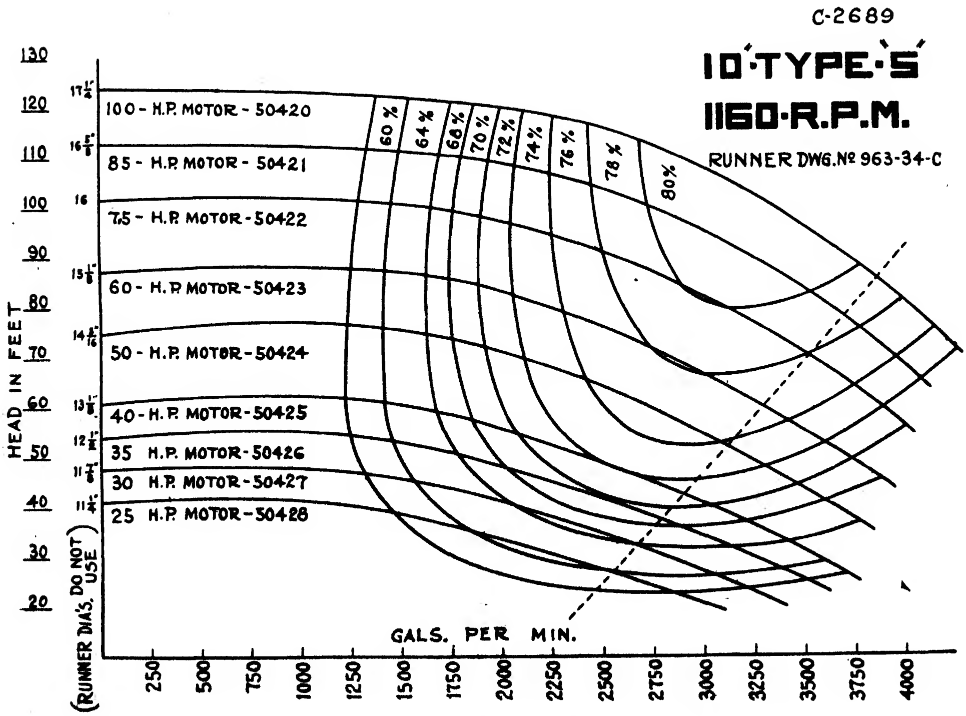

C-2689
10" TYPE "S"
1160 R.P.M.
RUNNER DWG. № 963-34-C
100 - H.P. MOTOR - 50420
85 - H.P. MOTOR - 50421
75 - H.P. MOTOR - 50422
60 - H.P. MOTOR - 50423
50 - H.P. MOTOR - 50424
40 - H.P. MOTOR - 50425
35 H.P. MOTOR - 50426
30 H.P. MOTOR - 50427
25 H.P. MOTOR - 50428
60%
64%
68%
70%
72%
74%
76%
78%
80%
HEAD IN FEET
(RUNNER DIA'S. DO NOT USE)
GALS. PER MIN.
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000

Fig. 4

above. The Brake Horsepower calculated for the point where the curve crosses the dotted line is the maximum value and indicates the greatest load which the pump can put on the motor under any conditions.

As variable speeds are not usually available on installations of motor-driven centrifugal pumps, the capacity can only be regulated by throttling either the suction or discharge connections. Partially closing either the suction or discharge valves increases the head and reduces the capacity in accordance with the characteristic curves. For pumps with a suction lift the total head change obtainable by throttling the suction is small. It is, therefore, better to do the necessary regulating on the discharge side.

The most progressive builders design and manufacture their pumps so that in each case they may be arranged to fit the exact conditions under which they may operate, to the best advantage. To accomplish this, the impellers are all cast to maximum size. On receipt of definite information as to operating conditions, the impeller is turned down to the exact size required, thus giving a choice of an almost unlimited number of runner sizes. This practice results in the highest possible efficiencies being obtained in each case. The charges against a centrifugal pump installation consist of a small amount for fixed charges and a relatively large amount for current. For this reason, high efficiencies have a greater effect on total costs than for other types when fixed charges are proportionally a much greater part of the total. It frequently happens that a few per cent better efficiency will easily justify a considerable difference in price.

Motor-driven centrifugal pumps except in very large sizes are usually shipped completely assembled on their common base plates. Although it is a comparatively simple matter to install them, it is very important that the aligning be very carefully done. A flexible coupling is usualy furnished between the pump and the motor, but this is only intended to take up motion horizontally and any misalignment is bound to interfere with proper operation and result in a short life for the coupling and excessive bearing loads. Great care must also be taken that the suction and discharge pipes are properly supported.

Although a centrifugal pump will operate with as high a suction lift as any other type, very high suction lifts are to be discouraged as a small leakage of air will interfere seriously with the capacity of the pump and may cause it to lose its suction entirely. Wherever possible water should not be raised to the pump over fifteen feet, as above that point there is a falling off in capacity. Where the water pumped is hot, as in the case of boiler feed, the suction lift possible is still further reduced and for temperatures above 170° F. there should be a positive suction head.

Unlike the displacement type, a centrifugal pump is not self-priming. It is essential, therefore, that it be entirely filled with water before it is started. On account of the small clearances between running and stationary parts operation for a very short time unprimed may cause serious damage. The method of priming depends on local conditions. The most common are by means of an independent vacuum pump, an ejector or a foot valve. The latter method should be avoided when possible as a foot valve is a frequent source of trouble and puts additional friction losses in the suction line, which should be as short and direct as possible and of ample size.

Centrifugal pumps can be divided into two classes, single stage and multi-stage. Owing to its much greater simplicity the single stage pump should be used wherever possible, unless due to unusual conditions a multi-stage pump can be supplied which will be sufficiently more efficient to warrant the higher cost. Frequently, the use of two or more single stage pumps in series will give a very satisfactory high head installation. Owing to continual improvement in design the heads for which single stage pumps can be obtained for efficient operation have been continually increased until now they are recommended for heads as high as 300 feet in the smaller sizes and up to about 200 feet for very large sizes. The single stage pump has the big advantage of being of the double suction type and is consequently automatically balanced. For multi-stage pumps it is necessary to provide some means of taking the unbalanced thrust and for this purpose the automatic hydraulic balancing disc has been found to be extremely satisfactory.

For ordinary conditions the closed runner type of pump has been found the most satisfactory and efficient. However, where water containing solids or grit is to be handled, the open runner type is preferable owing to its tendency to clear itself of obstructions and being less subject to wear.

Along with the many mechanical improvements in design of centrifugal pumps, efficiencies obtainable today are far in excess of what was thought possible a few years ago. Efficiencies as high as 86 and 87 per cent are now common, and these efficiencies are maintained over quite a wide range in operating conditions.

From being a cheap and inefficient machine that was only justified in unusual conditions, the centrifugal pump has come to be recognized as an efficient and valuable auxiliary in manufacturing processes and as a means of pumping liquids, which, due to its simplicity, is well worth serious consideration.

Non-Condensing Electric Generators*

By J. H. Grainger

In discussing this subject it is necessary, on account of the brief time and space allotted, to touch upon only the most important points to be considered in arriving at a conclusion as to which type of prime mover is best suited to meet the requirements for sugar mill service. Doubtless the practice in the sugar factories in Hawaii, as regards the several types of prime movers used for this service, is generally characteristic of the other cane sugar producing countries. Here we have the following types of prime movers driving generators, and operating with initial pressures ranging from 80 lbs. to 150 lbs. saturated steam and exhausting to back pressures ranging from 0 lb. gage to 10 lbs. gage:

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

Steam turbines;
Corliss engines;
Poppet valve engines;
Uniflow engines.

There are, of course, a number of slide valve and piston valve engines driving small generators, but for generators 300 k. w. and larger, these four types of prime movers doubtless cover the field. And to go still further, it is perhaps safe to say that at least 85 per cent of the total sugar mill generator capacity in Hawaii is either steam turbine or Corliss engine driven.

Expansion of Steam

Since the days of Watt, the economy of using steam expansively has been fully recognized and has perhaps reached its ideal in the steam turbine operating with the highest possible initial steam pressure, and the lowest possible vacuum on the exhaust.

The effort is to obtain the maximum number of expansions with a minimum amount of internal condensation. The releasing valve gear of Corliss gave us the desired range of expansion for prevailing steam pressures, and the compound and other multiple expansion engines later reduced the internal condensation by dividing the range of temperature among a number of cylinders instead of having it all occur in one.

The steam turbine through its ability to utilize a high degree of vacuum carries the expansion of steam to its practical limit, and due to the fact that each row of blades is operating at practically a constant temperature, internal condensation is minimized.

However, the steam turbine is not, under ordinary pressures, as economical as the reciprocating engine, the records for thermal efficiency still being held by reciprocating pumping engines, the superiority of the turbine lying in its ability to utilize higher pressures and temperatures than is practical with reciprocating engines.

Corliss Engines

The Corliss engine is one in which the point of cut-off is controlled by a governor acting directly through a releasing valve gear.

For a period of forty years, and until superseded by the steam turbine, this type of engine was the recognized American standard for economy, durability and general excellence.

The ordinary semi-rotative Corliss valve actually is a "D" slide valve made in four pieces, so that each cutting edge is separately adjustable, with the additional advantage that the point of cut-off is variable without affecting the other functions of the valves.

This type of valve is balanced as soon as moved off the lap, but unbalanced and held tightly to the seat when closed, and due to the use of a "wrist plate" motion, the valves have practically no movement when in the closed and unbalanced position.

The criticism has been made that a valve of this type soon leaks, due to wear, but this is entirely erroneous, because while the valve is a complete cylinder, it is intended to fit only a small segment of the cylinder, and the two surfaces wear parallel to each other, and the valve remains tight almost indefinitely, and engines which have been in service for more than forty years are today making as good indicator diagrams as when new.

The Corliss engine is limited in speed, due to the releasing valve gear, to between about 100 r. p. m. for the very largest sizes, to 150 or even 175 r. p. m. for the smallest sizes.

Owing to the rubbing surfaces which must be lubricated, the Corliss valve is limited to a maximum steam pressure of about 175 lbs., and to a total temperature of about 500° F., but for any pressure of 175 lbs. or under, or any steam temperature up to 500° F., the Corliss engine is equal in economy, and superior in durability to any other type of reciprocating steam engine.

Poppet Valves

Poppet valves are usually of the double seat type, and being practically balanced and having no sliding surfaces, are suitable for higher pressures and temperatures than Corliss valves. For pressures above 175 lbs., or temperature above 500° F. either poppet valves or balanced drop piston valves should be used. The principal objections to poppet valves are that they are difficult to keep tight, as their expansion is affected by temperature; they are exceedingly delicate of adjustment; and the cams with which they are operated require great skill in manufacture, and careful attention in operation. In brief, for ordinary speeds, pressures and temperatures, Corliss engines will be found fully as economical as the poppet valve engines, and much easier to maintain. They also require less skilled operators.

It is evident therefore that there is nothing to be gained by the use of poppet valve engines with comparatively low initial steam pressures and temperatures and high back pressures such as prevail in sugar factories.

"Uniflow" Engines

In the "Uniflow" engine, the effort is to obtain a high number of expansions with a minimum amount of internal condensation. In compound or other multiple expansion engines, these results are accomplished by dividing the expansion, and consequently the range of temperature between two or more cylinders. The expansions are usually about twice as many as would be used on a simple engine of the Corliss type, or about half as many as would be employed in a compound engine operating with the same steam pressure.

To prevent the initial condensation which would ordinarily result from the short cut-off, high compression is used to restore the heat to the clearance space, and consequently also the cylinder head is steam jacketed as well, so that the incoming steam does not meet any cold surfaces.

The Uniflow engine partially accomplishes the results aimed at, its economy under proper conditions being measurably greater than that of a simple engine

operating with less expansions, but inferior to that of the compound engine operating with a greater number of expansions.

Clearance volume in a cylinder is recognized as the greatest obstacle to high economy, and, therefore, the Uniflow engine is most economical when operating with a high degree of vacuum, because with such a vacuum the clearance may be kept low without danger of compression running above the initial steam pressure.

For non-condensing conditions, however, and particularly where back pressures are employed, as in process work, the Uniflow engine shows no superiority in economy, because with atmospheric or higher back pressures, the clearance volume must be made very large in order to prevent over compression; or auxiliary exhaust valves must be employed which brings the machine down to the economy of the four-valve class with the added disadvantages of the Uniflow cylinder and piston construction.

The name Uniflow is really a misnomer, because after the point of cut-off in a cylinder, there is no "flow" of steam, but an expansion in all directions; and when the exhaust port is opened, it is entirely immaterial whether the steam rushes out at the center of the cylinder or at the end. But there is, it is true, some advantage, in that the piston covers the cold exhaust port at the time steam is admitted.

Due to the fact that a single cylinder engine responds quicker to the governor than does a compound engine with a receiver, the Uniflow engine, if operated condensing, is well adapted for service where the load fluctuations are severe, as in rolling mill work; but for fairly steady loads, the compound engine is superior in economy at no greater first cost; while for the non-condensing or back pressure conditions, the simple Corliss engine is superior and has a considerably lower first cost.

Incidental objections to the Uniflow engine are the general objections to poppet valve gear, but more particularly to the difficulties of lubrication, especially where high pressures and temperatures are employed.

Compound and Multiple Expansion Engines

The employment of compound or other multiple expansion engines is determined by the operating conditions, chief among these being steadiness of load.

Non-condensing compound engines have about the same economy as simple condensing engines, and are usually employed either where water is not available for condensing, or where the exhaust is desired for process work. The non-condensing compound engine has a comparatively narrow range of load capacity, depending on the back pressure employed. The compound condensing engine may be employed to advantage in all cases where the load is reasonably steady, for while it will take care of wide variations in load, its best economy is at an average predetermined load. The triple or (quadruple) expansion engine can only be employed to advantage where the loads are quite steady and known at the time the machinery is designed, such load conditions occurring principally in pumping engines, and marine engines on ships making long voyages.

The use of such engines for fluctuating loads or for short periods is of no economic advantage, and of considerable mechanical disadvantage, and the same remarks apply to steam turbines.

Steam Turbines

The steam turbine is essentially a heat engine, and due to the fact that there are no rubbing contacts within the cylinder, with the consequent necessity for internal lubrication, it is better adapted mechanically to utilize much higher steam pressures and temperatures than are considered practical for reciprocating steam engines.

A steam turbine when operating condensing carries approximately 50 per cent of its load in the low pressure stage where the entering steam pressure, under ordinary conditions, is usually less than the pressure required for process work. It is evident, therefore, that we cannot expect as good steam economy from the turbine when operating against back pressure in the exhaust, as can be realized with a Corliss engine with a variable cut-off controlled by the governor.

The steam turbine has a decided advantage over any other type of prime mover for process work, in that it requires no internal lubrication, and consequently there is no lubricating oil to contend with in the exhaust steam.

The turbine also in practice uses less lubricating oil for the bearings, inasmuch as it is usually equipped with a self-contained lubricating and filtering system which permits of using the oil over and over again with practically no loss.

As compared with a reciprocating engine of the same capacity, the turbine requires somewhat less space and foundation work, and is therefore cheaper to install.

On the other hand, it is very necessary in turbine operation to maintain more constant steam pressures for satisfactory operation, and to see that the turbine is furnished with dry steam, free from acid or gas-forming impurities, such as are almost unavoidable in sugar factories at times.

General

Let us assume the following steam conditions:

Initial Pressure	125 lb. gage
Back Pressure	10 lb. gage

These conditions involve such a limited number of expansions that they are best met in an economical and practical way by the use of a simple engine. In fact at about 20 lbs. back pressure there is no difference in economy between Simple, Compound and Uniflow engines—they will reach a common point—and from the standpoint of steam economy, the turbine lags far behind.

Fig. 1 illustrates the above point. The upper diagram illustrates the expansion in an ideal engine without clearance, which shows that you would have five and one-half expansions to just reach a terminal of 10 lbs. back pressure, and that a 22″ steam cylinder would be required to deliver 420 k. w. at point of best economy at 900′ piston speed.

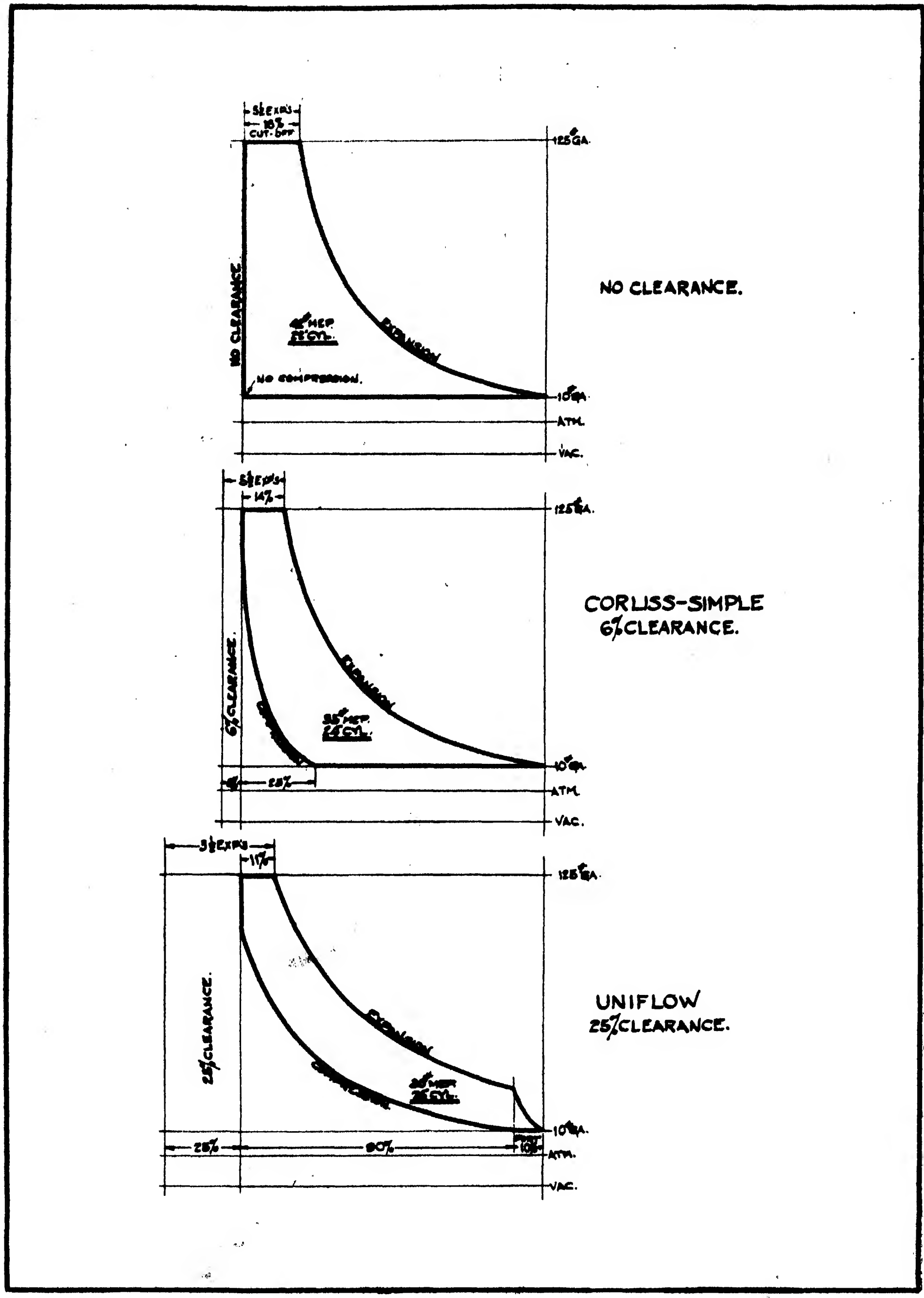


Fig. 1

The center diagram is for a simple Corliss engine with 6 per cent clearance and shows that five and one-half expansions with a 14 per cent cut-off would give an expansion line just reaching a terminal pressure of 10 lbs., and this would require a 24″ cylinder to do the same work as the theoretical 22″ cylinder shown in the upper diagram.

The lower diagram is for a Uniflow engine, which in order not to have the compression run above the boiler pressure, would require a clearance of about 25 per cent (or the use of auxiliary exhaust valves which are only used when an engine must run both condensing and non-condensing), and we would get a cut-off of about 11 per cent with three and one-half expansions, for, if we made a greater number of expansions, the cut-off would be so short that the indicator diagram would be exceedingly small, and the size of the cylinder abnormally large. On the same basis of speed as the simple Corliss engine the Uniflow would require a 26″ cylinder.

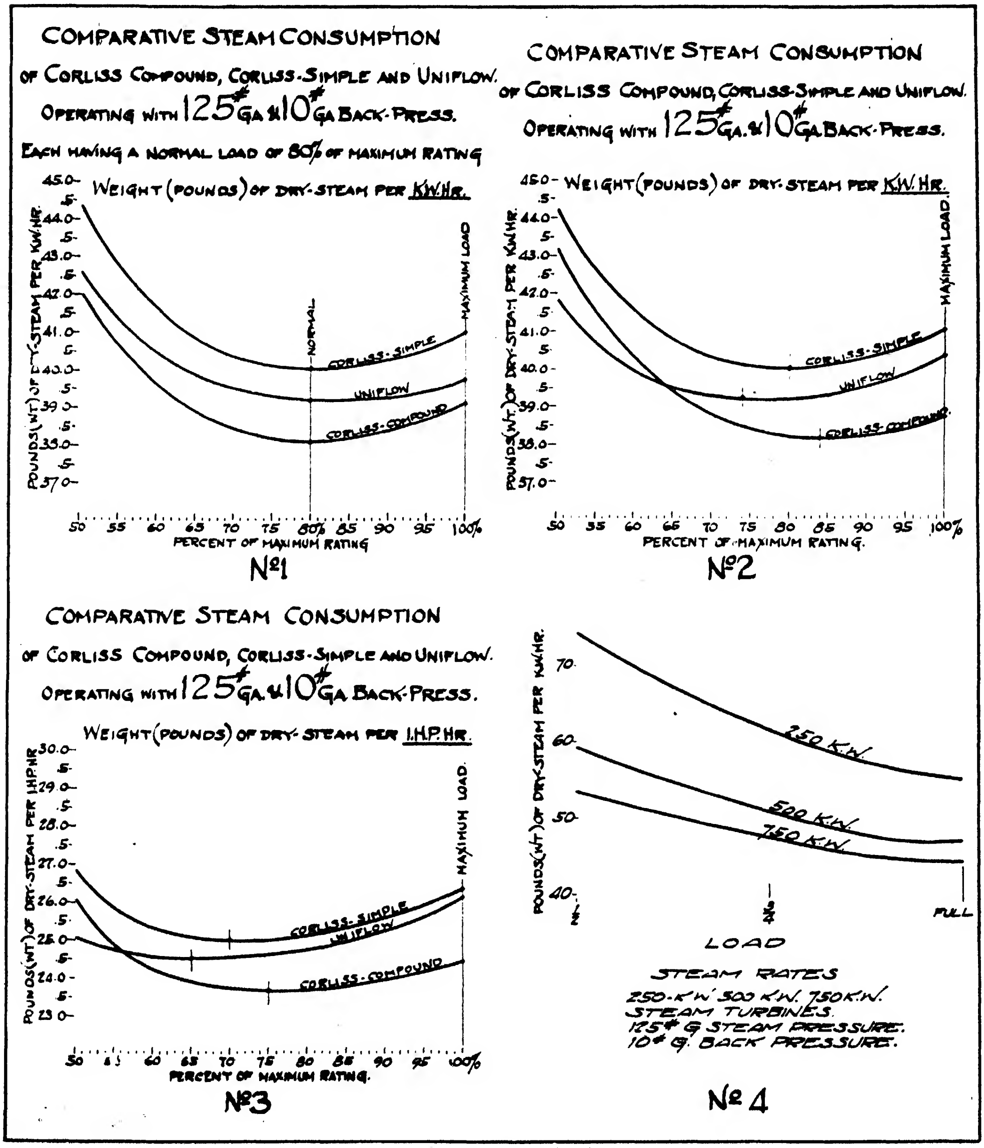


Fig. 2

A compound engine would make the same number of expansions as the simple Corliss, i. e., five and one-half, but they would, of course, be divided between the two cylinders.

Steam Economy

No. 1, Fig. 2, shows the relative steam economy of the simple Corliss, the Uniflow and the Corliss compound *based on their point of maximum economy* being at 80 per cent of the full load, the Corliss figures being from standard curves, while the Uniflow is taken from the best information obtainable from all sources, and, if anything, represents a better condition than would ordinarily obtain.

No. 2, Fig. 2, shows the relative steam consumption per *k. w. hr.* of the three types of engines *as usually rated;* that is, with the simple Corliss giving its best economy at 80 per cent load, the Uniflow at 74 per cent, and the compound Corliss at 84 per cent. These curves take into account the generator efficiency at the varying loads, and, therefore, represent the economy of the unit.

No. 3, Fig. 2, gives the relative steam consumption per *i. h. p. hr.* of the three types of engines, and indicates that the most economical point for the simple Corliss is 70 per cent of the maximum load, of the Uniflow 65 per cent, and of the Compound 75 per cent.

These curves have all been made on the basis of a 500 k. w. maximum rated unit, but there would be no substantial difference for either a 250 k. w. or 750 k. w.

No. 4, Fig. 2, shows the approximate steam rates of 250 k. w., 500 k. w. and 750 k. w. steam turbine per k. w. hour from half load to full load.

Sizes and Prices

The following table gives the cylinder sizes, r. p. m., best load (most economical point), steam per k. w. at point of best economy, and price f. o. b. works of 250, 500 and 750 k. w. maximum rated units in simple Corliss, compound Corliss and Uniflow types. The factory price for the three sizes of steam turbine is also given. The figures for the simple Corliss engines, compound Corliss engines and steam turbines are based on Allis-Chalmers Mfg. Co. standard data, while the Uniflow engine figures are taken from the best informaton available.

COMPARISON OF SIMPLE CORLISS, COMPOUND CORLISS AND UNIFLOW ENGINES OF 250, 500 AND 750 K. W. (MAX. RATED, STEAM 125 LBS. SATURATED) 10 LBS. BACK PRESSURE

		A	B	C
	Max. Rating	250 K. W.	500 K. W.	750 K. W.
	Cylinder	16″ x 36″	22″ x 36″	26″ x 42″
	R. P. M..............	150	150	120
Simple	Best Load............	200 K. W.	400 K. W.	600 K. W.
Corliss	Steam per K. W. Hr....	40 Lbs.	40 Lbs.	40 Lbs.
	Price at Works	$10,000.00	$13,000.00	$19,000.00

	Cylinders	14" & 22" x 36"	18" & 28" x 36"	22" & 36" x 42"
	R. P. M.	150	150	120
Compound	Best Load	210 K. W.	420 K. W.	630 K. W.
Corliss	Steam per K. W. Hr.	32.2 Lbs.	38.15 Lbs	38.05 Lbs.
	Price at Works	$14,500.00	$18,000.00	$26,000.00
	Cylinder	18" x 30"	28" x 36"	32" x 42"
	R. P. M.	180	150	125
Uniflow	Best Load	185 K. W.	370 K. W.	560 K. W.
	Steam per K. W. Hr.	39.25 Lbs.	39.2 Lbs.	39.15 Lbs.
	Price at Works	$15,000.00	$22,500.00	$33,000.00
Turbine	Price at Works	$11,000.00	$15,000.00	$19,000.00

Tasseling*

By O. C. Markwell

In order to avoid confusion, this subject will be treated in the following manner:

1. Tasseling of mature or second season canes.
2. Tasseling of immature or first season canes.
3. Influencing factors.

Tasseling of Mature Canes

The tasseling of mature canes is desirable or undesirable in so far as it increases or decreases the yield of sugar. It is supposed that tasseling affects the juices. If this is true, then the percentage of canes which tassel during the second season is a figure to be considered. With the above supposition in mind, W. C. Jennings offers the following data, which he secured at Hawi Mill and Plantation Company:

JUICE ANALYSIS OF TASSELED AND UNTASSELED CANE, FIELD HOEA 9 SAMPLES GROUND IN HAND-MILL AND ANALYZED

January 8, 1924

Sample		Brix	Pol.	Pur.	Q. R.
D 1135	Tasseled	16.4	13.83	84.3	9.76
	Untasseled	15.2	12.87	84.7	10.51
Yellow Caledonia	Tasseled	18.6	16.51	88.7	7.98
	Untasseled	19.1	17.16	89.9	7.66
H 109	Tasseled	16.4	14.05	85.7	9.57
	Untasseled	15.8	13.73	86.9	9.7

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

Striped Mexican	Tasseled	18.7	16.92	90.5	7.73
	Untasseled	18.6	17.31	93.06	7.43

The H 109 tasseled so heavily and the Yellow Caledonia so lightly that it may detract somewhat from the value of comparisons in these varieties.

March 16, 1924

Sample		Brix	Pol.	Pur.	Q. R.
D 1135	Tasseled	18.8	16.79	89.3	7.85
	Untasseled	18.9	16.30	86.3	8.23
Yellow Caledonia	Tasseled	20.8	18.93	91.	6.89
	Untasseled	20.9	19.29	92.3	6.69
H 109	Tasseled	20.1	18.65	92.8	6.92
	Untasseled	19.7	18.93	96.	6.72
Striped Mexican	Tasseled	19.8	19.01	96.	6.68
	Untasseled	19.6	18.93	96.5	6.70

April 26, 1924

D 1135	Tasseled	20.0	18.22	91.1	6.51
	Untasseled	19.8	17.71	89.3	6.63
Yellow Caledonia	Tasseled	19.6	17.48	89.1	6.70
	Untasseled	20.9	18.74	89.6	6.28
H 109	Tasseled	21.1	20.05	95.0	6.05
	Untasseled	20.7	19.82	95.7	6.15
Striped Mexican	Tasseled	20.9	19.29	92.3	6.18
	Untasseled	20.4	19.99	97.9	6.19

For D 1135 there is a consistent beneficial effect, while with Yellow Caledonia the opposite is true. This data does not give sufficient evidence to enable one to draw a definite conclusion.

The following counts were made in five different locations in Field Hoea 9 to determine the percentage of tasseling. Only the inside lines were counted, taking the third, thirteenth and twenty-third in a watercourse in each locality:

H 109

Line No.	Total Stalks	Total Tasseled	Total Untasseled	Percentage of Tassels	Remarks
1	39	36	3	92	3 very thin stalks not tasseled
2	77	72	5	94	5 smaller than average stalks not tasseled
3	74	67	7	91	5 very thin stalks not tasseled, 2 larger but still below average
4	63	59	4	94	1 very thin and 2 smaller than average not tasseled
5	78	70	8	90	All thin stalks
6	93	86	7	93	5 very thin and 2 smaller than average
7	103	102	1	99)	
8	89	88	1	99)	Untasseled stalks smaller than average
9	109	107	2	98)	

10	91	88	3	97	3 thin stalks
11	91	82	9	90	7 very thin and 2 near average
12	79	70	9	89	6 small and 3 near average
13	84	79	5	94	Untasseled stalks all thin
14	87	82	5	94	1 very thin and 4 below average
15	92	85	7	92	6 small and 1 near average
				—	
Per cent of tasseled stalks......				93	

Every line in two watercourses was inspected, but no stalks that had not tasseled were found which approached the average in size.

The following counts were made in the third and thirteenth lines of a watercourse in six different locations in Field Hoea 9:

Striped Mexican

Line No.	Total Stalks	Total Tasseled	Total Untasseled	Percentage of Tassels	Remarks
1	76	65	11	86	3 small stalks, 8 below average in size, 7 very small
2	98	86	12	88	3 below and 2 average stalks, 8 very small
3	104	85	19	82	11 below average, 4 very small
4	69	60	9	87	2 below and 3 average, 2 very small
5	82	74	8	90	2 below average
6	91	79	12	87	12 below average, 5 very small
7	97	83	14	86	9 below average
8	83	77	6	93	6 below average, 7 small
9	107	89	18	83	11 below average, 1 small
10	96	88	8	92	7 below average, 5 small
11	87	76	11	87	7 near average
12	93	86	7	92	5 near average, 2 small
13	86	77	9	90	8 below average, 1 small
Total...	1169	1025	144	88	

In the Striped Mexican quite a large percentage of stalks had evidently started to arrow and then stopped. No further growth takes place at the tip and the interior of the sheath is dead. These stalks are counted as having tasseled.

The following counts were made in the third line of a watercourse in five different locations in Field Hoea 9:

D 1135

Line No.	Total Stalks	Total Tasseled	Total Untasseled	Percentage of Tassels	Remarks
1	92	86	6	94	1 small, 5 average circumference stalks
2	89	81	8	91	5 small, 3 average circumference stalks
3	111	95	16	86	8 very small, 8 below average circumference stalks
4	106	87	19	82	6 small, 13 below average circumference stalks
5	101	90	11	89	11 all below average circumference stalks
Total....	499	439	60	88	

In both D 1135 and H 109 untasseled stalks are, as a rule, either very small in circumference, or have subnormal appearing stalks or large suckers. The suckers, or any stalks which are apparently second season growths, are disregarded in making counts.

The tables showing the percentage of tasseling, which Mr. Jennings presents, contain some interesting remarks. While they do not settle the question, they emphasize the necessity of further endeavor along this line.

In the following data, supplied by Richard Penhallow, it is interesting to note that there is a big difference in the amount of tasseling among the standard varieties under different environment. Count was made at the end of December, 1923:

Striped Mexican

Field No.	Plant or Ratoon	Percentage of Tassel	Remarks
3	Ratoon	27	Mauka
4	"	63	"
5	"	57	" (1st ditch, lower)
5	"	32	" (2nd ditch, upper)
6	"	34	"
86	"	45	"
86	"	50	"
86	"	43	"
24	Plant	51	"
3	Ratoon	57	"
3	"	50	" Inside valley
13	"	2	" Tasseled heavily last year
14	"	57	"
16	"	39	Ordinary elevation
41	"	60	" "
67	Plant	70	" "

H 109

Field No.	Plant or Ratoon	Percentage of Tassel	Remarks
6	Ratoon	35	Mauka
38	Plant	59	"
38	"	53	"
39	Ratoon	43	"
43	"	44	"
9	"	36	Makai
31	Plant	41	Ordinary elevation
31	"	76	Very heavy cane along bank of stream
31	"	79	Makai
99	Ratoon	30	Ordinary elevation, rainfall slight
40	"	51	" "
42	Plant	41	" "
56	Ratoon	40	" "
57	"	29	" "
55	Plant	64	Makai
60	Ratoon	50	"

Lahaina

95	Ratoon	33	Makai, heavy cane
95	"	Few	Poor spot
95	"	20	Makai, good cane
95	"	35	Ordinary elevation, fair cane
95	"	50	" " very good cane
66	"	61	" "

Yellow Caledonia

7	Plant	5	Mauka
8	Ratoon	5	"
7	Plant	5	"
8	Ratoon	5	"

H 146

6	Ratoon	20	Mauka
9	"	14	Makai
20	"	19	Ordinary elevation

D 1135

13	Plant	16	Mauka, light stand
67	"	36	Ordinary elevation, good stand

Badila

31	Plant	2	Ordinary elevation

Wailuku 3

31	Plant	2	Ordinary elevation, good cane

Wailuku 6

31	Plant	11	Ordinary elevation, good cane

Tasseling of Immature or First Season Canes

Tasseling of immature or first season canes is undesirable because it decreases the yield. Cut-back experiments should prove or disprove this for any given variety and locality. Into our cut-back experiments has entered a factor which some think has worked to the disadvantage of cutting back. This will be discussed under influencing factors.

Varieties: The time of tasseling and the length of time required to mature their seed differ with the varieties.

In general, of our standard varieties, H 109 and D 1135 are the highest in tasseling percentages, while Yellow Caledonia and Striped Mexican are comparatively light. H 146 is our earliest tasseler, although it does not mature its seed as quickly. Badila comes in flower among the late ones, and H 5001 seldom tassels. However, Richard Penhallow says that at Wailuku it was observed tasseling in November, after less than a year's growth.

He also made the following comparisons as to the time of the year different varieties tassel:

Wailuku, Maui, Ordinary Elevation, November 3, 1923

D 1135—tasseling in all fields.
Lahaina—tasseling in some fields.
Striped Mexican—a few tassels in some fields.
H 109—a few tassels in some fields.
Wailuku 4, 13, 5 and 11—very few tassels.

Richard Penhallow states that Wailuku 22 never tassels. Some Hawaiian canes are said to never flower. From observation and what can be learned from the older residents of Kauai, the Hawaiian variety, Puaole, does not tassel.

It should be comparatively easy to classify varieties and seedlings according to their general habits of tasseling. It might be well to consider such a classification where tasseling should be avoided.

Influencing Factors

Relative to observations on factors influencing tasseling, you will note the remarks and notes attending the data of W. C. Jennings, which he summed up by saying: "In both D 1135 and H 109 untasseled stalks are, as a rule, either very small in circumference, subnormal appearing stalks, or large suckers."

The above observations are partially corroborated by Richard Penhallow, who says:

In the middle of November I made counts in three varieties and recorded them as follows:

Variety	Per cent Tassel	Remarks
W 5	2.4	Mauka line where growth was short
W 5	8.2	
W 5	17.7	Mauka line where growth was exceptionally long
W 5	25.5	
W 5	19.6	Mauka line—short growth.
W 5	43.0	Makai line—heavy growth
W 9	8.75	Normal line in hollow
W 9	4.5	Growth retarded by nut grass
W 9	34.6	Mauka line—very heavy growth
W 9	1.2	Mauka line—poor stand
W 9	1.14	Good growth
W 9	32.9	Very heavy growth

In Wailuku 4 a few tassels were noticed where growth was very heavy, but none on the pali where growth was poor.

In a gulch at McBryde Sugar Company, differences in the time and amount of tasseling of Yellow Caledonia, ratoons, were noted as follows:

A—High pali, protected from wind, practically unirrigated, only two or three tassels appeared.

B—Bottom of gulch, heavy cane, most mature, had sufficient water. Tasseled earlier and heavier, about 15 per cent.

C—Pali, wind swept. At time of tasseling of "B" about 5 per cent tasseled. As late as February more tassels appeared. Total 10 per cent.

Of the above data, Richard Penhallow says:

The cane had very good growth for its age. The fact that the cane grew so fast shows that a great deal of vigor was in the plants. When growing conditions became adverse, this vigor had to be turned to something else and the cane, already large enough, turned it to producing seeds.

No doubt the difference in amount of tasseling in the above observations is due to environment. Of environment's role in tasseling W. W. G. Moir writes:

I feel reasonably certain from observations and data secured from many varieties under different environmental treatment that the greatest factors in preventing severe tasseling, in the susceptible varieties, and none in the very slightly susceptible ones, are regularity and uniformity of environment at least three months prior to the regular tasseling period. This regularity may be good or poor agricultural practice as long as it is uniformly carried out from beginning to end and not a mixed practice.

Examples of this may be cited here: A field of H 109 harvested at an elevation of 800 feet in January was neglected entirely until July 1 when it was weeded, fertilized and irrigated. At that time half of the field was cut back, and had regular uniform treatment up to tasseling time. The area which was not cut back tasseled only 8 per cent and had about 30 tons of cane per acre, while the cut-back cane with no tasseling had less than 5 tons of cane per acre.

There were far more shoots per line in the non-cut-back, but they had not the strong appearance that would bring them through to maturity. There is another process going on at this stage in the growth of both the cut-back and the non-cut-back cane, which will be discussed later, which tends to even up the yield for a period of the growth.

Here we have given a case where the treatment of the crop was what you would call poor agricultural practice (neglect). The neglect was uniform and regular, that is, at no time was the place given any agricultural treatment of any kind until regular and uniform plantation work could start—5 months after harvesting.

In another field at a little lower elevation (in general), the lower the elevation the less tasseling in H 109 as observed under conditions here (Maui), the H 109 was harvested at the same period, but was prepared for the next crop immediately by weeding, irrigating and fertilizing, but due to the lack of a willing contractor the agricultural practice was irregular, the periods between irrigations varying from 12 to 30 days. This continued up to tasseling time. The percentage of tasseling was around 30 per cent. In an adjoining field a piece of H 109 was harvested about the same time, but not treated, practically neglected, except for weeding. Yet it tasseled only 10 per cent.

In still another field the H 109, harvested at the same time but taken up, was given regular plantation treatment in regular and uniform doses. Here the process continued regularly throughout the crop and less than 5 per cent tasseling was recorded.

So we can feel reasonably certain from these cases, together with several other corroborative experiments or observation inserts, that the prime factor influencing tasseling is environment, and that we secure heavier tasseling with irregular environment and practically none where the environment is kept either uniformly severe or uniformly good.

Mr. Moir continues to explain his stand on cutting back as previously referred to:

As mentioned above, I said there was a tendency to equalization of yield in both the cut-back and non-cut-back areas. In cutting back a crop you are starting it all over

again and its rate of growth becomes much more rapid than does a crop that has been stunted and neglected. This difference in rate of growth continues until the second season growth starts. The cut-back area may appear to surpass the non-cut-back for a period, but beginning with the second season a "grand reawakening," as you might call it, happens to the non-cut-back area. Extremely great numbers of large, strong, secondary shoots appear. These are so numerous and strong that one wonders how so many stalks may find room in a line to grow. From then on if your growing conditions are ideal enough, the non-cut-back area will far out yield the cut-back, even though they at one time became equalized.

Mr. Moir believes that "extra" tasseling along the watercourse is due to lack of uniform environment, while Penhallow thinks that it is due to the additional growth of the cane, which in turn is due to environment.

At any rate there may be some basis for the criticism of our present cut-back experiments.

F. W. Broadbent, Maui, says:

It appears to me thus far that unless fields of ratoons can be given a proper start soon after harvesting, it is more profitable to cut them back later, and start them off. An argument based on tassel percentage is not too sound because the stand of the no-cut-back stuff is not up to that which has been cut back.

He suggests cut-back experiments as follows:

1. No-cut-back cane that is started soon after harvest.
2. No-cut-back cane that is started per plantation schedule.
3. Cut-back cane started per plantation schedule.

In January, 1924, marked differences in tasseling were noted in two experiments at Koloa Sugar Company. These experiments were located in Field 51 in the mauka section, elevation about 600 feet. Upon investigation the following data were obtained:

Experiment 17—Amount of Reverted Phosphate, 1925 Crop—Yellow Tip Cane, Planted April, 1923—Tassels Counted January 22 and 23, 1924

A— 500 pounds of reverted phosphate per acre.
B—1000 pounds of reverted phosphate per acre
C—1500 pounds of reverted phosphate per acre
D—None

Tassel Count

Plots	Average per Row Tassels	Average per Row Sticks	Percentage
A	38.5	215	19.25
B	18.75	234.5	8.00
C	18.25	235	7.76
D	61.5	184.25	33.7

For the first few months phosphate did not appear beneficial. Subsequently, however, canes of "B" and "C" plots showed marked gains. In nearby experiments, Field 51, no response to nitrogen or potash is visible.

No doubt there is a high mortality of sticks in the no-phosphate plots, for it was observed during the tassel count that many of the small sticks were dying.

In Experiment 14, Plant Food, Field 51, tassel counts were made and the data secured corroborates the results of the tassel count of Experiment 17.

Experiment 14—Plant Food—Yellow Caledonia, Planted March, 1923

Plots	No. of Plots	Average per Row Tassels	Average per Row Sticks	Per cent Tasseling
N	5	5	99	5.05
NP	5	3	116	2.58
NK	5	6	102	5.88
NPK	5	3	111	2.7
PK	5	2	122	1.64

All plots which received phosphate had 1,000 pounds reverted per acre in furrow before planting.

The writer interprets the above results as indicative that the heavy tasseling of the canes of the A (500) and D (none) plots was due to stunting, which in turn was due to marked unavailability of the plant food element, phosphorus. He believes that in a soil showing a strong response to nitrogen or potash, similar results would be obtained.

Blind Eyes

Inquiries were made relative to the cause and occurrence of blind eyes. Most observers associate their occurrence with tasseling. The few long joints below a tassel have no eyes. It has been noted that blind eyes correspond to the tassel season. It has been suggested that the blind eyes are formed by the same influence which causes tasseling, but that the influence is not strong enough to cause tasseling, so normal growth is resumed when eyes again form.

Concerning blind eyes, A. D. Shamel asserts that there is some evidence involving the terrific competition under which canes labor.

Executives Want to Save Dollars, Not Heat Units*

In the industrial plant, the operating engineer often feels that the factory management regards the power plant as a necessary evil, something to be put up with for want of a better method of turning the wheels in the production departments, but something on which no money is to be spent except in a case of dire necessity. The plant engineer feels this most keenly when he approaches the management with a request for new equipment that will raise the efficiency of his boilers and engines. He finds that the management often has little patience with his troubles and he cannot understand why, because his needs are so evident to himself.

* Power Plant Engineering, Vol. XXVIII, No. 24.

The reason for his apparent lack of interest will be clear when we consider that the executive thinks in terms of business and finance, not engineering. He thinks of the total cost of the factory's product, of first costs, interest on investment; fixed charges, depreciation and the like. If he is not an engineer himself, the executive thinks of the power plant simply as a place from which to obtain as cheaply as possible the power necessary to turn the wheels of the production departments.

Yet this very attitude taken by so many executives gives the engineer a chance to show the management that here in the power producing department is an opportunity to cut costs that has too often been overlooked. The principles of good salesmanship apply here. The proper stand for the engineer to take is that the question is one of business policy, that by investing a definite amount of money in equipment carefully selected to decrease the fuel consumption and pay for itself within a definite time, a material reduction can be made in the cost of supplying power. An approach to this subject from this viewpoint will arouse the instant attention of the executive, whereas the recital of technical woes often leaves him cold.

It goes without saying that in presenting his case in this way, the engineer will be prepared to prove his point, like any other good salesman. For example, if he needs a new feed-water heater, he can find out without much trouble how much the heater will cost, the depreciation on it, the cost of maintenance, the interest on the investment, and the fuel saving that will result from its use. Then he can show how in a definite time, considering past averages, the saving will pay for the heater and how, after that time, the power cost will be reduced by just that much, allowing, of course, for the replacing of the heater at the end of its life.

In attempting to raise the efficiency of his plant, the engineer can secure the interest and co-operation of the management if he will remember that they are primarily interested in saving dollars, not heat units or power units. Without too much trouble, he can translate his technical information into business terms. When he does this, he finds that, after all, the management is interested in his work.

[Keep the boiler or power plant clean and neatly painted. Cleanliness in a plant promotes pride, and pride in one's work means better and more careful work.]

[W. E. S.]

Sugar Prices

96° Centrifugals for the Period March 17, 1925, to June 18, 1925

Date	Per Pound	Per Ton	Remarks
Mar. 17, 1925	4.755¢	$95.10	Cubas, 4.77; Porto Ricos, 4.74.
" 18...........	4.71	94.20	Porto Ricos.
" 19...........	4.74	94.80	Cubas.
" 25...........	4.71	94.20	Cubas.
" 26...........	4.68	93.60	Porto Ricos.
" 30...........	4.65	93.00	Porto Ricos.
" 31...........	4.62	92.40	Cubas, 4.65; Philippines, 4.59.
April 1...........	4.59	91.80	Porto Ricos.
" 7...........	4.52	90.40	Porto Ricos.
" 8...........	4.535	90.70	Porto Ricos, 4.52, 4.55.
" 9...........	4.52	90.40	Porto Ricos.
" 14...........	4.505	90.10	Cubas, 4.52, 4.49.
" 15...........	4.445	88.90	Porto Ricos, 4.43, 4.46.
" 16...........	4.40	88.00	Cubas.
" 22...........	4.385	87.70	Porto Ricos, 4.40, 4.37.
" 27...........	4.40	88.00	Cubas.
" 28...........	4.365	87.30	Cubas, 4.33, 4.40.
" 29...........	4.315	86.30	Cubas, 4.33; Porto Ricos, 4.30.
" 30...........	4.27	85.40	Cubas.
May 1...........	4.33	86.60	Cubas.
" 12...........	4.365	87.30	Porto Ricos, 4.33; Cubas, 4.40.
" 13...........	4.43	88.60	Cubas, 4.40, 4.46.
" 14...........	4.315	86.30	Cubas, 4.33; Porto Ricos, 4.30.
" 18...........	4.30	86.00	Porto Ricos.
" 19...........	4.285	85.70	Cubas, 4.30; Philippines, 4.27.
" 20...........	4.27	85.40	Philippines.
" 23...........	4.33	86.60	Porto Ricos.
" 25...........	4.365	87.30	Porto Ricos, 4.33; Philippines, 4.40.
" 26...........	4.43	88.60	Porto Ricos, 4.40; Cubas, 4.43, 4.46.
" 27...........	4.41	88.20	Porto Ricos, 4.46, 4.37; Cubas, 4.40.
" 29...........	4.37	87.40	Cubas.
June 2...........	4.43	88.60	Cubas, 4.40, 4.46.
" 4...........	4.445	88.90	Porto Ricos, 4.46; Cubas, 4.43.
" 10...........	4.40	88.00	Porto Ricos.
" 16...........	4.46	89.20	Cubas.
" 18...........	4.43	88.60	Porto Ricos.

THE HAWAIIAN
PLANTERS' RECORD

Volume XXIX. OCTOBER, 1925 Number 4

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

The Transmission of "Rosette" Disease of Peanuts by an Aphis

Messrs. H. H. Storey and A. M. Bottomley,* of South Africa, have demonstrated that the disease in the ground nut or peanut (*Arachis hypogea*, L.), known in South Africa as "rosette", is transmitted by *Aphis leguminosae* Theo. This disease belongs to the virus group, to which the mosaic of sugar cane also belongs. These two workers believe "rosette" to be identical with "Krauselkrankheit" of Zimmermann in East Africa, with the "Krulziekte" of Rutgers in Java and with the bunching or "clumping" in West Africa and India. About nine species of Homoptera which feed upon peanut were experimented with, but all except *Aphis leguminosae* gave negative results.

This work has interest for us: first, on account of our work with sugar cane "mosaic" and, second, demonstrating how important it is to keep out of Hawaii all insects which may be capable of conveying plant diseases.

F. M.

* Nature, No. 2907, Vol. 116, p. 97, July 18, 1925.

Cut-back vs. Not-cut-back Experiment

By H. B. PENHALLOW

This experiment was carried out by the plantation in Field 92 with H 109 ratoon cane under the usual plantation conditions to determine the effect of not cutting back, as cutting back has been considered necessary at Wailuku, due to the prevalence of heavy tasseling there in all varieties of cane. Prior to the present experiment various small plots have been under observation, indicating that cutting back might be dispensed with under certain conditions. The present experiment, carried out on a sufficiently large area to give more conclusive results, shows a definite gain from not cutting back in H 109 ratoons.

The area involved in this experiment covered 71.30 acres of H 109 ratoons, of which 38.36 acres were cut-back and the remainder, 32.94 acres, not-cut-back. The plots consisted of 10 alternating not-cut-back level ditches with 9 cut-back ditches, thus sufficient repetitions were assured.

The field was harvested during February and March, 1925. The cane from the various plots was carefully weighed and sampled under special supervision.

The previous crop was harvested during the months of March and April, 1923, and cutting back took place June 23 to 27.

Fertilization consisted of an application of B-7 at the rate of 1,000 pounds per acre in the latter part of August and an application of 170 pounds of nitrogen from nitrate of soda in the latter part of November, 1923.

The cut-back ditches required three more weedings than did the not-cut-back ditches.

In regard to tasseling, the following notes were made on or about the 8th of December, 1923: "In Field 92 there is very little tasseling (only one here and there) in the first ditch above the Government Road, which showed most dryness from lack of water several months ago, and no tasseling in the cut-back ditches. The other not-cut-back ditches have more tassels, mostly along the level ditches, straight ditches and watercourses. If a tassel count should be taken in the spots where there is heaviest tasseling, between 10 per cent and 15 per cent tasseling would be evident."

That heavy tasseling did not take place in the not-cut-back ditches was further substantiated at harvesting by the fact that not a great number of lalas were to be found. Stalks which did have lalas were found mostly along level ditches and watercourses where, as mentioned above, the most tasseling took place. Stalks with all the way from 1 to 4 lalas were found, the average running about 2. Average length of lalas was about 5 feet while the main stalk ran from 4½ to 5 feet.

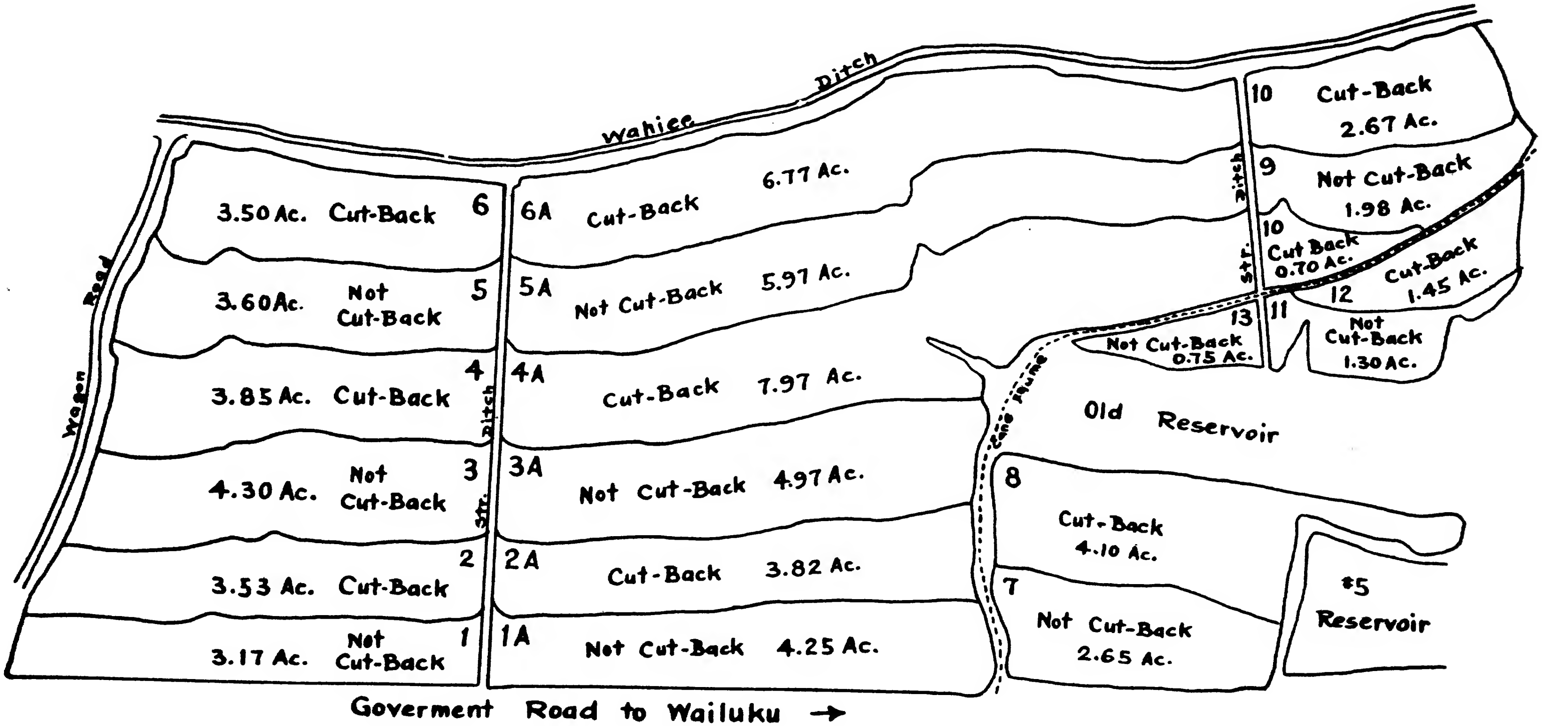
As can be seen from a study of the results obtained, the not-cut-back ditches outyielded the cut-back ditches in tons cane per acre and also gave a better quality

WAILUKU SUGAR CO.

Field 92.

Cut-back vs Not Cut-back

1925 Crop



ratio. This is possibly due to the extra period of growth in the not-cut-back ditches and also the cane in them being more mature.

A similar experiment is to be harvested in 1926, in which the not-cut-back area showed 34 per cent tassels by count, which is considerably higher than in the one just harvested.

WAILUKU SUGAR COMPANY

Cut-back vs. Not-cut-back

Field 92—Crop 1925

Ditch No.	N. C. B. or C. B.	Area	Total Tons Cane	Tons Cane per Acre	Q. R.	Tons Sugar per Acre N. C. B.	Tons Sugar per Acre C. B.	Total Tons Sugar N. C. B.	Total Tons Sugar C. B.
1	N. C. B.	3.17	238.475	75.23	6.99	10.76		34.13	
2	C. B.	3.53	245.385	69.51	7.04		9.87		34.85
3	N. C. B.	4.30	307.790	71.58	7.08	10.11		43.48	
4	C. B.	3.85	266.225	69.15	7.21		9.59		36.92
5	N. C. B.	3.60	262.310	72.86	7.08	10.28		37.00	
6	C. B.	3.50	241.325	68.95	7.38		9.34		32.69
1A	N. C. B.	4.25	299.145	70.39	6.81	10.33		43.93	
2A	C. B.	3.82	249.270	65.25	6.98		9.34		35.69
3A	N. C. B.	4.97	327.845	65.96	6.78	9.73		48.37	
4A	C. B.	7.97	500.357	62.78	7.07		8.88		70.83
5A	N. C. B.	5.97	381.331	63.87	6.85	9.32		55.65	
6A	C. B.	6.77	393.923	58.18	7.21		8.07		54.63
7	N. C. B.	2.65	180.435	68.09	6.76	10.07		26.70	
8	C. B.	4.10	245.135	59.79	7.01		8.54		35.04
9	N. C. B.	1.98	118.970	60.08	7.02	8.55		16.93	
10	C. B.	3.37	180.972	53.70	7.16		7.50		25.30
11	N. C. B.	1.30	78.462	60.35	7.38	8.18		10.64	
12	C. B.	1.45	81.765	56.39	7.57		7.45		10.80
13	N. C. B.	.75	43.712	58.28	6.71	8.68		6.51	

SUMMARY

	Area	Total Tons Cane	Tons Cane Per Acre	Q. R.	Sugar
Not-cut-back	32.94	2238.475	67.96	6.92	9.82
Cut-back	38.36	2404.357	62.68	7.14	8.78
In favor of Not-cut-back.........			5.28		1.04

Blind Seed in H 109

By J. N. P. Webster, Agriculturist, Wailuku Sugar Company

In cutting top seed in fields of H 109 just previous to harvesting, the finding of blind seed, joints without eyes, is of common occurrence. Unless seed cutters watch carefully, out of ten bags cut, from one to two bags of blind seed can be found.

Some seem to think that the appearance of blind seed is a sign that H 109 is going back or degenerating. An instance being found in some seedlings which cannot be extended on account of their not developing eyes. From some observations made recently by the writer this does not seem to be the case.

The field in which the observations were made is laid out in a cut-back vs. not-cut-back experiment, the cane in the not-cut-back ditches being slightly over a year old and tasseling having taken place in November and December, 1924.

A number of primary stalks in a not-cut-back level ditch were examined and it was found that while some had tasseled, others had not. Those that had tasseled were sending forth all the way from 1 to 5 lalas. Fig. 1 shows a group of 4 lalas about 4 months old.

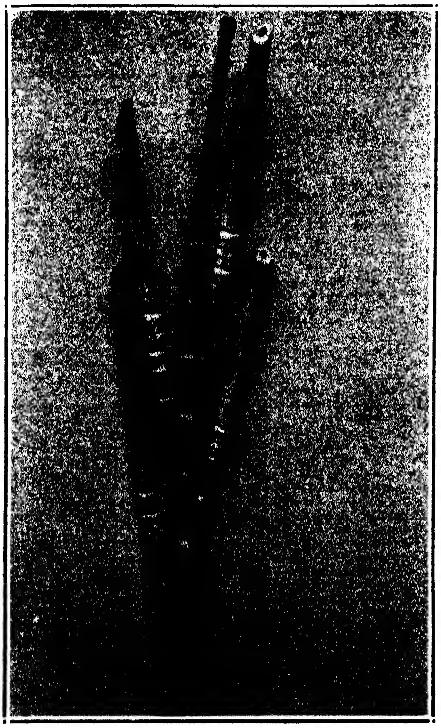


Fig. 1

On the primaries which had not tasseled it was found that, although they appeared to be normal stalks, there was a blind section just beneath the last dry leaf, consisting of anywhere from 5 to 8 nodes. In some instances there were signs of a very small, poorly developed eye, but mostly none at all.

These primaries were practically the same age as those tasseling and the blind sections were noted at a point corresponding, more or less according to the growth, to a section just above the lalas of the tasseled stalks. This last mentioned section is always blind and is a natural characteristic of stalks tasseling.

On all the stalks gone over it was found that above the blind section normal eyes were again being developed. See stalk No. 2 in Fig. 3. Apparently, by some instinct of nature, there is a period of disagreement as to whether a stalk is to reproduce itself by tasseling or not. This causes eyes to stop forming, with the result that we have a blind section covering the period of disagreement.

If it were a case of H 109 going back one would think that with a blind section commenced it would keep on being blind, but this, as pointed out above, is not so.

Furthermore, blind sections have been seen just recently in Lahaina, Striped Mexican, Wailuku No. 5 and Wailuku No. 9, so that this is not a condition peculiar to H 109. That Lahaina develops this feature has been known on Maui for a number of years—probably on other islands as well.

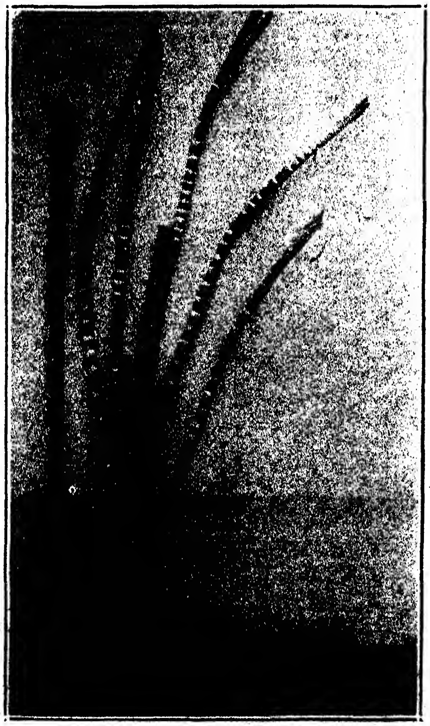


Fig. 2

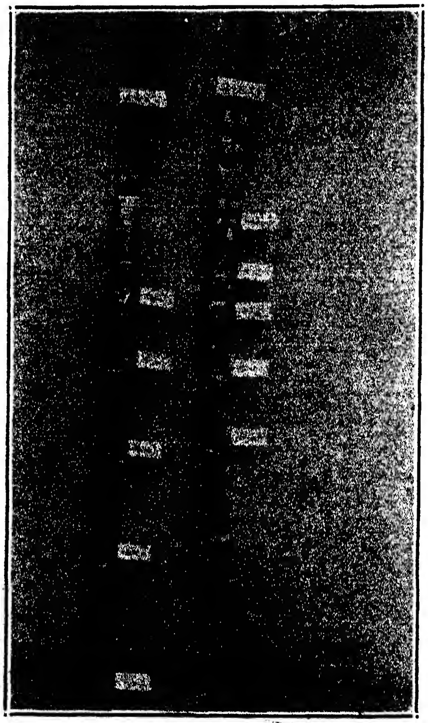


Fig. 3

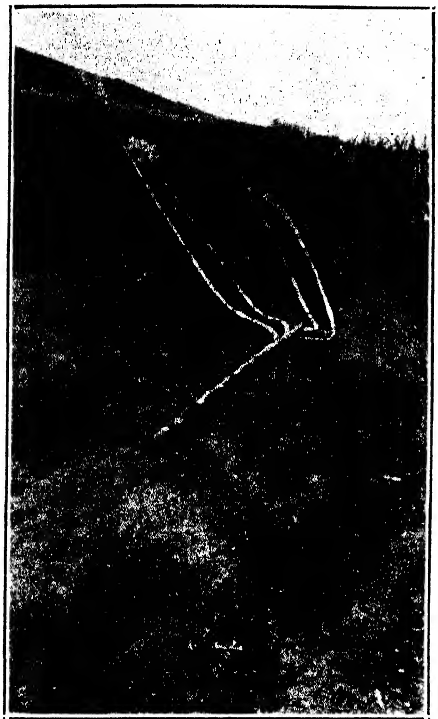


Fig. 4

Fig. 5

The abnormal condition noted on stalk No. 1 in Fig. 3 is no doubt the result of a more aggravated period of indecision—whether to tassel or not. Eyes above this part are normal.

In a not-cut-back level ditch of two-year old cane, stalks were found which (1) had not tasseled in two tasseling seasons, (2) others while tasseling in the first season did so in the second, and (3) still others which tasseled in the first season, lalaed, and the lalas tasseled in the second season.

Stalks under (1) above were found to have two blind sections, one about the middle of the stalk and the other at the top. See Fig. 5, which is a whole stalk cut into three pieces. The blind section of the first season can be seen in the middle piece and that of the second season in the piece to the right. Note that all the eyes above the first blind section are normal up to the point representing the tasseling period of the second season, which is blind, then normal eyes again start forming.

Figs. 2 and 4 fall under (3).

The Root System of Sugar Cane

By J. A. Verret

When a sugar cane cutting is planted, as we all know, roots are produced from the root bands at the nodes. The question is often asked as to how long these roots can function, and of what use they are in supplying nourishment to the growing cane.

Very little has been done along this line and we find no reference to it in the literature.

In order to get some information on this, a test was recently started in pots at Makiki.

Seed pieces of the same size were taken, each having three joints. The two end eyes were gouged out of each seed piece.

In two of the pots the cane was allowed to grow normally. These are pots marked A and E, Fig. 1. In the other pots only the roots growing from the seed

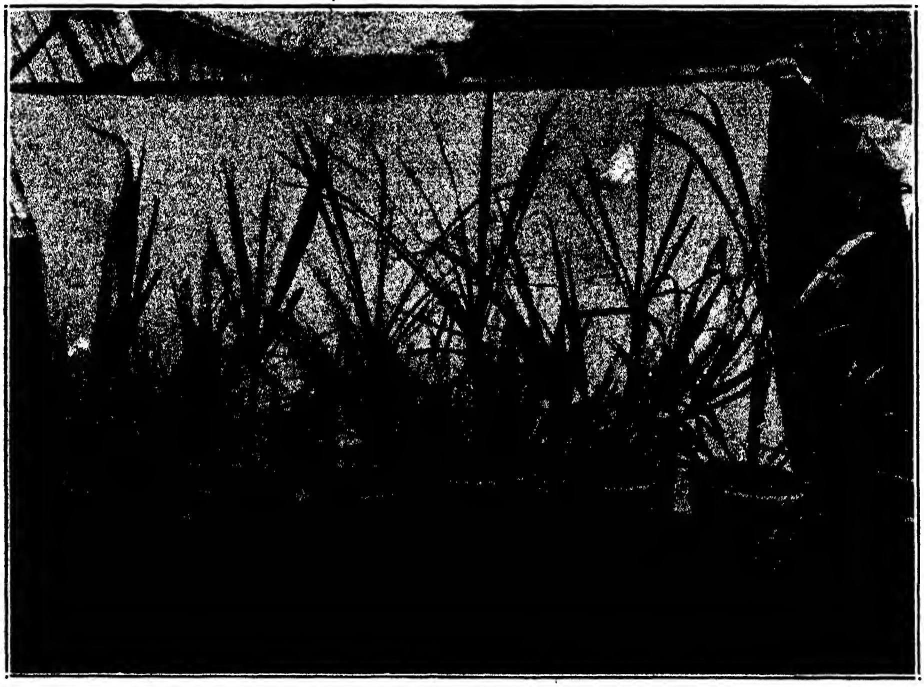


Fig. 1

piece were allowed to grow, those coming from the shoots were cut off as they appeared. This was done with sharp scissors so as to cause the least disturbance to the growing plants (Figs. 3 and 4).

The cane remained in the tubs seven months, at which time the stools were dug out and the photographs herewith reproduced were taken.

The tubs were somewhat small and the cane did not make normal growth, but, nevertheless, some very interesting results were obtained.

In the tubs from which the roots of the shoots were cut off, it was found that the roots from the seed piece were alive and functioning. The seed pieces were alive and fresh looking (see A and E in Fig. 2). They were not soured and contained apparently as much sugar as when planted. This shows that, if necessary, the growing cane can obtain its food indirectly. The roots on the seed piece transfer the food material to the seed piece, from which, in turn, it is taken up by the growing cane. This can go on for at least seven months.

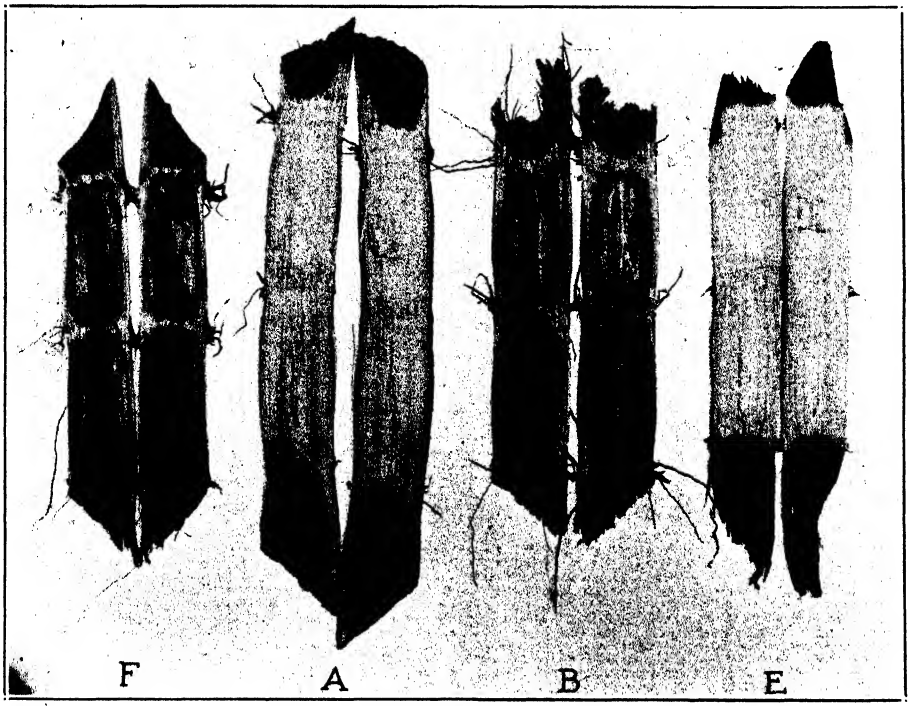


Fig. 2

Conditions were different in the pots in which no roots were trimmed. In these pots the "seed piece" roots were almost all dead, the living ones being from the growing stalks. The seed pieces were shrunken and rotted away. The "seed piece" roots apparently ceased to function as soon as the stalks had roots of their own. When this took place, organisms invaded the seed piece and it began to decay. (See B and F, Fig. 2.)

In the case where the roots were trimmed, the plant was compelled, as previously explained, to obtain its nourishment indirectly through the seed piece. This made the seed piece an integral part of the growing plant and it remained healthy.

From this, it is but a step to the field and some of our practices where we can theorize as to what takes place. When it is necessary to off-bar, when is the

Fig. 3. This shows the complete root system when none of the roots have been trimmed.

proper time to do it? Most of us think the sooner the better. Reasoning from the above results, this may be wrong. The old roots of the stool are still functioning. As long as they do, the stump will remain healthy, as the living plant has the power to resist invading organisms. Now, if we come along and off-bar deeply and cut off the living old roots before new shoots have appeared and formed roots of their own, we stop all life and the old stump will immediately begin to rot. Of course, we never cut off all the roots in off-barring and this takes place only in part.

From the above, it would seem that the ideal time to off-bar is after the ratoons have begun to grow, but before their roots have attained such length as to be cut in off-barring. In this way, we keep the old stump alive until the new stalks are self-supporting.

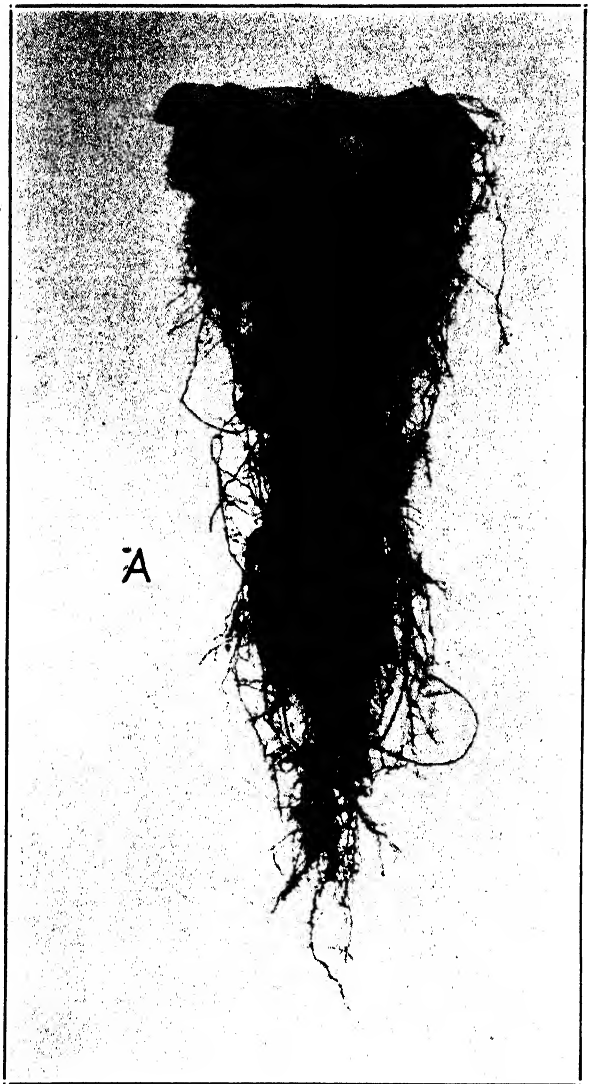


Fig. 4. The root system of the seed piece planted in pot A.

U. K. Das, who had active charge of the test, supplies the following details of the work:

Materials

Pots: Six concrete pots were selected. Three of them, marked A, B and C, had a capacity of about 0.9 cubic feet, the other three marked D, E and F, of about 0.6 cubic feet. All the pots were filled with a soil mixture consisting of field soil and mud press in equal proportions.

Seed Pieces: Three-joint, one-eye seed pieces were taken from young H 109 cane and planted on November 9, 1924.

Fig. 5. The root system of seed piece planted in pot B where the roots have been trimmed from the growing stalk.

PROCEDURE

Planting: The cuttings were planted in the concrete pots on the morning of November 9, 1924, at a depth of about an inch. The pots were kept in an open place.

Irrigation: All the pots received uniform irrigation (the size of the pot being taken into consideration) during the whole period of the experiment.

Weeding: All the pots were weeded at regular intervals.

Trimming: As soon as the adventitious roots appeared, they were trimmed off with a pair of sharp scissors with the least possible injury to the plants. This was done every two or three days during the initial stages of the experiment and at longer intervals during the later stages.

Growth Measurements: After the plants had grown to a sufficient length, monthly growth measurements were taken till the end of the experiment.

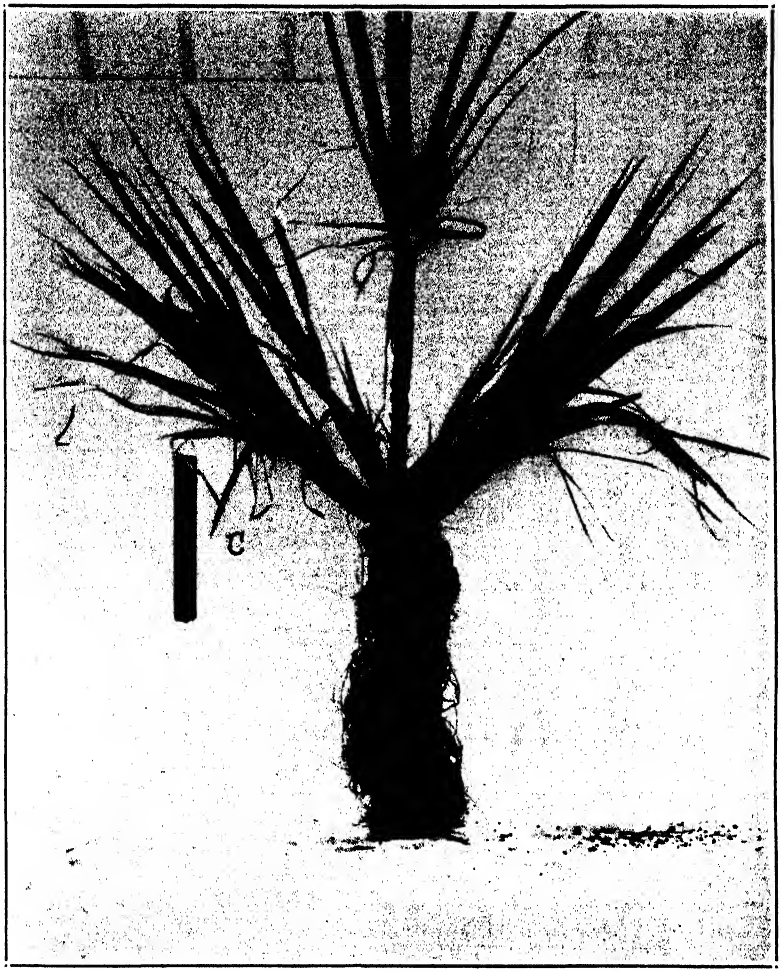


Fig. 6. Pot C, which received the same treatment as pot B shown in Fig. 5.

Results

The young shoots began to appear on November 19, or ten days after planting. The growth thereafter was rather slow. The first adventitious roots were detected in some pots on December 28, 1924. From this time on, and for about three months, there was a brisk appearance of such roots in all the pots.

Controls

The idea of keeping control pots did not come until a little later. On January 18, two pots, one from among the three big sized pots, and one from among the three small sized ones, were marked "checks." Thereafter no roots were clipped off from the plants growing in these two pots.

There was no marked difference in growth and development of the plants. The following figures were obtained on the growth of the plants:

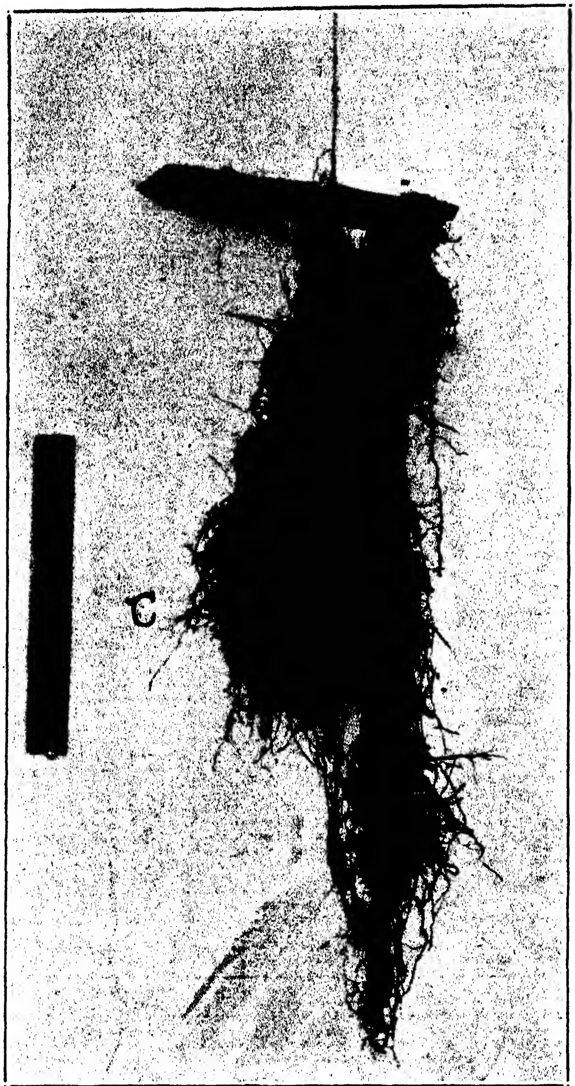


Fig. 7. The root system of seed piece planted in pot C where roots have been trimmed.

TABLE 1

Pot	1924 Dec. 10 To top of leaf	1925 Jan. 18 To topmost dewlap	1925 Mar. 16 To topmost dewlap	1925 Apr. 16 To topmost dewlap	1925 May 18 To topmost dewlap	1925 June 8 To topmost dewlap
A	1.83′	1.12′	1.81′	1.92′	2.13′	2.22′
B (check)	1.79′	.94′	1.65′	1.80′	2.00′	2.12′
C	1.75′	.96′	1.51′	1.62′	1.75′	1.80′
D	1.08′	.92′	1.34′	1.45′	1.63′	1.68′
E	1.66′	.93′	1.31′	1.37′	1.61′	1.66′
F (check)	1.08′	.91′	1.46′	1.57′	1.77′	1.91′

Fig. 8. Pot F, which received the same treatment as Figs. 5 and 6.

TABLE 2

Actual Growth of Plants

Pot	Jan. 10 to Mar. 16	Mar. 16 to Apr. 16	Apr. 16 to May 18	May 18 to June 8
A	.69′	.11′	.21′	.09′
B (check)..	.71′	.15′	.20′	.12′
C	.55′	.11′	.13′	.05′
D	.42′	.11′	.18′	.05′
E	.38′	.06′	.24′	.05′
F (check)..	.55′	.11′	.20′	.14′

During the latter stages of the experiment it was evident that all the plants were suffering from lack of nutrition.

It further appeared that the shoots arising from the mother plant in check pots were slightly bigger than the ones in the other pots, but the number of shoots were more numerous in the other pots. The following figures were obtained on June 8, 1925:

TABLE 3

Pot	Total No. of Shoots	No. of Shoots Bigger Than 0.5′
A	13	7
B (check)	8	6
C	12	7
D	8	6
E	7	6
F (check)	6	6

TABLE 4

Pot	Total Length of All Shoots Bigger Than 0.5′
A	5.24′
B (check)	7.07′
C	5.64′
D	4.00′
E	4.95′
F (check)	5.18′

For the purpose of comparison, the pots may be put into two classes, the bigger pots, A, B, C, in one class and D, E, F in another.

On June 16, the plants were removed from the pots and the soil washed away from the roots.

It was found that every plant had a thick and compact root system, but in the case of some plants, there was no root system corresponding to one or two nodes of the seed piece:

A—All joints of the seed piece have root system.
B—All joints of the seed piece have root system.
C—One joint has none, while another has few roots.
D—Two joints have no root system.
E—All joints have root system.
F—One joint has no root system.

This information may help us to explain some of the growth measurement figures.

It was also observed that the check Pots B and F had more numerous living, healthy roots than others. The living roots (those only which had the color of newly germinated roots) were counted.

Pot	Number of Healthy Roots	
A	80	
B (check)	128	
C	10	(These figures are by all means only approximate)
D	21	
E	8	
F (check)	68	

On cutting the seed pieces it was found that the tissue in seed pieces A and E was of normal color and taste.

The illustrations are by the Pathology department.

Comparison of Juices in Pith and Rind

By Wailuku Sugar Company

In the following experiment mature cane about twenty months old was used. Stalks were cut into lengths of about two feet and the rind sliced off as thin as possible with a cane knife. The piths and rinds were then run through the hand mill separately:

		Brix	Pol'n	Purity	Q. R.
W 2	Pith	20.16	18.95	94.0	6.7
	Rind	20.16	18.44	91.5	7.1
Lahaina	Pith	22.16	21.07	95.0	6.0
	Rind	22.56	21.04	93.3	6.1
	Composite	22.36	20.99	93.9	6.1

Hand mill juice samples taken of fields previous to harvesting checked fairly closely with the actual results obained at the mill, except in the case of W 2. The above experiment was run in order to determine whether or not the difference of purity between pith and rind had any bearing on the matter, because of the more complete crushing done in the factory as compared with that of the hand mill, which no doubt would give a larger proportion of rind juice in the factory sample.

We intend carrying out similar tests in the coming season to give us more definite data.

The Early Work of Albert Koebele in Hawaii

By R. C. L. Perkins

It was in 1890 that Koebele sent *Novius cardinalis* to Honolulu from California, where he had previously established it. Its success in controlling the cottony cushion scale, then one of the worst insect pests in the United States, had come to the notice of Mr. Jaeger, of Honolulu, who was interested in agriculture and horticulture, and it was through his sagacity that specimens were obtained from Koebele and introduced into Hawaii. As every one who pays any attention to such matters is aware, at this time, and previously, the above-mentioned pest was fully as destructive in the Islands as in California (where, of course, the interests were much greater) and some other "blights," as these insect pests were frequently termed, were almost equally destructive.

Thus we read that coffee, which had been introduced in 1825, by the middle of the century had become quite an industry on Kauai, but this was abandoned in 1856 owing to the ravages of "blight" said to have been introduced in 1850.

In 1876, the Rev. T. Blackburn, an expert entomologist in Honolulu, wrote that "the fruit trees were afflicted with an incurable blight."

The success of the *Novius,* which soon became manifest, led to Koebele's subsequent engagement partly by the Hawaiian Sugar Planters' Association and partly by the Government, as was urged by Mr. Jaeger.

Early in 1892, the writer became acquainted with Mr. Jaeger, who was naturally very enthusiastic, not only about what had already been achieved, but as to what further success Koebele might attain. He was very much surprised when informed that the latter's work as an entomologist was little, if at all, known except in the United States.

In 1894, many Coccinellidae were introduced by Koebele, chief among which were *Cryptolaemus montrouzieri* and *Coelophora inaequalis.* In the earlier literature the latter is unfortunately always referred to as "*Coccinella repanda,*" the name used by Koebele, and it was not till many years afterwards that we received named specimens of the true *repanda* from Australia and became aware of this error.

Probably either of these two ladybirds was even more valuable to the Islands than the *Novius,* owing to the fact that they preyed on pests which seriously attacked a larger number of plants than did the cottony cushion scale.

In 1892, throughout the Kona district, where I was then stationed, *Pulvinaria* covered many of the trees, which were in a dying condition and many, in fact, were dead. After the *Cryptolaemus* was taken there, this scale to a large extent disappeared. There may be some who still remember the strange appearance of the trunks of many of the larger ornamental trees in Honolulu in June, 1896, when the *Cryptolaemus* larvae, having become full-grown, congregated together so as to form large white patches covering several square feet of the surface, which was entirely hidden by them. Owing to the white covering of the larvae many people mistook these for scale insects and were actually destroying them. Photographs were taken of some of these tree trunks and copies are probably still extant in the possession of the Territorial Board of Agriculture and Forestry.

In June, 1895, many of the native trees in the kipukas that are found in the forest at various parts within eight or ten miles of the crater of Kilauea were covered with a conspicuous black Aphid and others less noticeable. Many of the *Pelea* trees, especially, were in a dead or dying condition, but other forest trees were affected. At this time single specimens of *Coelophora* were rarely noticed, having evidently just arrived at the locality. In September, the ladybirds were in thousands and when the same places were revisited in August, 1896, we were unable to find even a single specimen of the large black Aphid.

Other ladybirds introduced at this early period were *Rhizobuis ventralis, Platyomus lividigaster* and *Orcus chalybeus,* all of which were more or less successful and useful. Others were fully established at large, but later became either scarce or totally extinct. The history of some of these is interesting. No species appeared more promising for a time than *Chilocorus circumdatus.* At first

the larvae became extraordinarily numerous, entirely clearing some trees of the harder scales, but gradually the beetle became rarer and rarer, till after 1900 I myself saw only a few single individuals. *Novius koebelei,* so far as we are aware, disappeared still earlier, and so far as we know *Synonyche grandis,* by far the largest of introduced ladybirds, was common for only a very short time on some of the ornamental bamboos in Honolulu. *Leis conformis,* from which much was expected, was almost entirely a failure. The pretty *Coccinella pupillata* was noticed from time to time, but not in great numbers.

During the earlier years of his work, Koebele's visits to Honolulu were short and few, his material being liberated by the Commissioner of Agriculture, Joseph Marsden. Whatever may have been the latter's knowledge of agriculture, of entomology he had none beyond that of a few Latin names, to repeat which gave him a good deal of pleasure. No doubt Koebele's chief success with ladybirds as compared with other insects was due to this fact, for when liberated, full instructions having been given as to the place where they were to be turned out, they could look after themselves. But many small parasites were also sent, and of almost none of these is there any record, except *Chalcis obscurata,* which became very abundant throughout the Islands. As Koebele informed me, his special request that all the dead material should be saved for subsequent identification, was not attended to in any instance.

Owing to my own occupation in the forests of the different Islands and to Koebele's infrequent visits to Honolulu, we did not happen to meet during the earliest years of his work, but on returning from a considerable stay in the Kauai forests in 1895, I found him in Honolulu. Among other matters, we discussed the possibility of his economic introductions proving antagonistic to my own work on the native fauna, especially as some of the rarer species of native Hemerobiids, which had been unusually numerous on the Aphis-infested *Pelea* trees at Kilauea, had disappeared after the introduced *Coelophora* had eaten up the Aphis. Reference was made to this point in a brief account of Koebele's work which I wrote in 1896 and which was published in the following year in *Nature.* Imperfect as this account was, it at least had the effect of calling the attention of most European countries to his work and its possibilities.

As it was necessary for me, after I had met him, to do further work in East Maui, I persuaded Koebele to accompany me and share my tent, since he was anxious to obtain some knowledge of the forest insects, concerning which there were complaints. After spending some weeks in the high, wet forest of the windward side, we left our tent, and carrying as few *impedimenta* as possible, we worked about the summit and through the crater to the lee side, sleeping in the open or in such natural shelters as were available. Being lightly clothed we were a good deal troubled by the sharp frosts at night, which appeared abnormally cold after the fine hot weather of the daytime. I have referred to this, the first of several hard trips we made together, as it gave me the first opportunity to see what a very accomplished field worker Koebele had become. He was particularly expert at collecting difficult beetles, and had no doubt learned many wrinkles from his friend E. A. Schwarz, of Washington, in earlier years.

In 1897, I joined Koebele in California and accompanied him to Arizona and Mexico, where he hoped to obtain some natural enemy for the mealybug of the alligator pear. This had now become an unsightly pest, having been introduced since the earlier years of my collecting. The complaints about Lantana were already numerous and some preliminary investigation was made of the plant in Mexico, but at this time no attempt was made to introduce any of the insects attacking it.

In 1898 and 1899, I was in England working at the *Fauna Hawaiiensis*, but on my return (early in 1900) to the Islands I was still more in contact with Koebele than previously, since we not only made many collecting trips in company, but I did much study work in his office.

In 1900, the presence of a number of insects entirely unknown to me in 1897 was obvious. Chief among these was the melon fly (*Dacus cucurbitae*) and the cane leafhopper. The latter was noted first as a leafhopper new to the Islands, at Waialua, where it occurred in some numbers around the electric lights in 1900. Its connection with sugar cane was not known at the time; in fact not until a year or two afterwards, when it was reported by August Ahrens as injuring the cane on Oahu Plantation. There is no doubt that as a pest it first showed up on that plantation and it was probably introduced, or at least became established there first, about the year 1897. Had this insect occurred in earlier years, it is unlikely (considering its attraction by light) that I should not have noticed it, and quite impossible that Koebele, who was perfectly well acquainted with the accounts of the Javanese *vastatrix*, and was frequently in the cane fields investigating the cane borer and other cane insects, should have overlooked it. In fact when he first saw the leafhopper in the Islands he took it to be the same as the pest recorded from Java.

Also in 1900, the fern weevil (*Syagrius*) was first noticed in fernhouses in Honolulu on maiden-hair ferns only, and the possibility of its spreading to the native tree ferns of the forest was not thought of.

The introduction of the melon fly must have taken place at about the same time. Up to the time when I left the Islands in 1897 melons were almost a drug on the market, and except possibly for the Chinese, could hardly have paid for raising. After my return, one of the first settlers in the agricultural colony at Wahiawa informed me that he considered the presence of the melon fly by no means a calamity, as he was able to raise melons by adopting certain precautions and obtain a good price for them, whereas formerly it would not pay to grow them. The species was first described in 1899 from specimens obtained by Mr. Compere in Honolulu. Koebele had, however, previously collected the species on one of his trips to the Orient, before it was known in the Islands, and had noted it as a pest on plants of the melon family. In 1900, I found Hawaiian melons and cucumbers were almost unprocurable. It does not appear that Koebele made any concentrated effort to obtain parasites for *Dacus*, possibly because Compere was specially investigating fruit flies at the time. In Mexico, when engaged on Lantana work, he noted a fine parasite on other fruit flies, but he would not take the risk of attempting to send over puparia of these flies, for fear that by some accident the flies themselves might be introduced. He was always cautious in his

introductions and many of the Australian ladybirds he was afraid to send in their larval state for fear of introducing their parasites.

In addition to the one species, *Chalcis obscurata,* above mentioned, Koebele sent over many other parasitic Hymenoptera from various countries, Australia, America and the Orient, at a time when he was the only economic entomologist connected with the Islands. Many of these were parasites of scale insects and *Aleyrodes,* but *Ichneumonidae* were sent from America and *Braconidae* from Oriental countries.

No record exists of the minute scale parasites which were frequently sent. For instance, it is quite uncertain whether some of the established parasites on scales were the results of his sendings or whether they came by other means, but it is hardly probable that of the large number of species sent none survived, even though they had no expert handling on arrival. As Koebele was well acquainted with the exact localities of the scale insects in various grounds and gardens in Honolulu and gave exact directions, as to where the parasites were to be liberated, a certain amount of success probably resulted. Although he never cared to make any attempt to introduce birds, various species of frogs, toads and bats were sent, but the latter at any rate failed to become established, though individuals were seen alive for a year after their introduction.

Of his later work on the Lantana plant, the sugar cane leafhopper and some other less important insect pests, fuller published records exist and can be consulted.

Koebele was *par excellence* a field worker in entomology and his knowledge of living insects was of a most extensive character, as at one time or another he paid special attention to all orders, but chiefly to Coleoptera and Lepidoptera, to some of the minute Hymenoptera and to scale insects. At one period he did much rearing of micro-Lepidoptera for Professor Riley. As may be judged from the nature of his field work, the Coccinellidae or ladybirds were his especial favorites, and he collected great numbers of species in the various countries he visited. He was not a great reader of entomological literature, but certain systematic works he used continually, e. g., Maskell's and Green's Coccidae, and especially Crotch's book on the Coccinellidae, which accompanied him on all his travels. Of the classification and specific character structures of these groups he had an extensive knowledge, though he published no notes of a systematic nature on others excepting some official reports and even these were to him an uncongenial task.

His success in the field was due to his acute perception of the habits of insects, and unsurpassed perseverance, and he was naturally a very quick worker, so that with insects that are rare and difficult to obtain he could collect a greater number in a given time than most of the best field workers we have known. Under any circumstances he was a most pleasant companion on a trip, for even when the hardest and most uncomfortable conditions were added to ill success he remained cheerful and good humored, hoping to the last to achieve something by which a failure might be converted into a triumph. He met with many adventures in his varied traveling, and in unhealthy countries contracted many fevers, which failed to lessen his enthusiasm for his work, but he rarely spoke of his adventures. In his younger days, when collecting in Florida, he was down with severe fever and

has told us how, at the time, numbers of a fine Sphingid moth, the caterpillars of which he had laboriously collected, were emerging in numbers in the room in which he lay, and how he spent the night alternately in killing the specimens, lest they should damage themselves, and in lying in a fainting condition on the floor. As would naturally be expected, he was the discoverer of great numbers of species of insects which were new to science, and many were named after him by their describers.

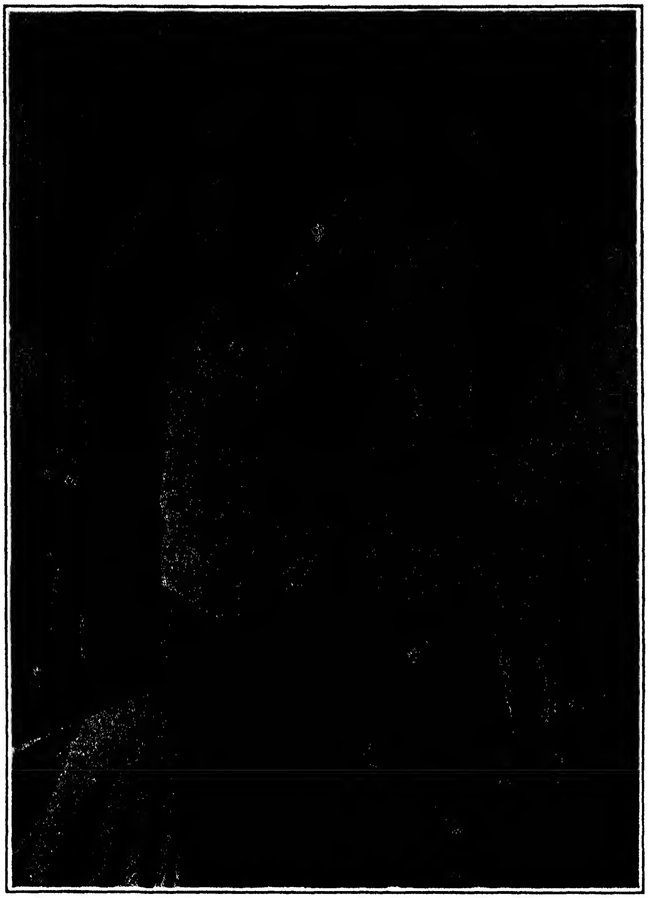
Biographical Sketch of the Work of Albert Koebele in Hawaii

By O. H. Swezey

Mr. Albert Koebele was the pioneer economic entomologist in the Hawaiian Islands. He was one of the first, if not the very first, entomologist to engage in the introduction of their natural enemies as a method of combating insect pests. His early work in this line was in California, where he introduced from Australia in 1888-89, the lady beetle *Novius cardinalis* Muls. as an enemy to the cottony cushion scale, *Icerya purchasi* Mask., a serious citrus pest. This was a remarkable success, and was considered to have saved the citrus industry from ruin.

At this time, Koebele was in the employ of the U. S. Department of Agriculture, an appointment which commenced in 1881-82. It was in 1885 that he was transferred to the Pacific Coast region, where he established his home at Alameda, California. During the several years that he was working in California he was chiefly engaged in the introduction of beneficial insects. Two trips were made to Australia for this purpose. This period of work ended on September 30, 1893, when he resigned from the U. S. Department of Agriculture to take up similar work in Hawaii, at first under a Commissioner of Agriculture of the provisional government, later as entomologist of the Board of Agriculture and Forestry, after the latter was organized, and about 1903 or 1904 was placed on the staff of the Experiment Station, H. S. P. A., as consulting entomologist, which position he held at the beginning of the Great War.

It has been impossible to obtain exact records of the work and travels of Mr. Koebele during his early work in Hawaii. However, during 1894-95, he made an extensive tour of Australia, Ceylon, China and Japan in search of beneficial insects desirable of introduction. Many lady beetles were introduced at this time. Among those which have become established and continue effective up to the present are *Cryptolaemus montrouzieri* Muls., *Rhizobius ventralis* Erich. from Australia preying on mealybugs; *Orcus chalybaeus* (Boisd.), *Serangium maculigerum* Blkb. from Australia, *Chilocorus circumdatus* Schon. from China, *Sticholotis punctatus* Crotch from China, all on diaspine scale insects; *Coelophora inaequalis* (Fab.), *Platyomus lividigaster* Muls., *Diomus notescens* (Blkb.) from Australia and *Coelophora pupillata* (Schon.) from Hongkong, all preying on



ALBERT KOEBELE
Enlargement from a snapshot taken in a Honolulu garden about 1900. (Courtesy of W. M. Giffard.)

plant lice. Among parasites that were introduced on this trip are *Chalcis obscurata* Walker and *Microbracon omiodivorum* (Terry), both from Japan and parasitic on leafroller caterpillars, the *Microbracon* being especially effective on the sugar cane leafroller.

In 1896-97 considerable time was spent in Mexico, Arizona and California, from which places large quantities of lady beetles were sent, also many kinds of cutworm enemies, but apparently these mostly failed to become established.

In 1899-1900, Koebele went on another trip to Australia, spending some time in Fiji on the way, and also going to Hongkong on the return voyage. Many shipments of beneficial insects were made on this trip, particularly from Australia.

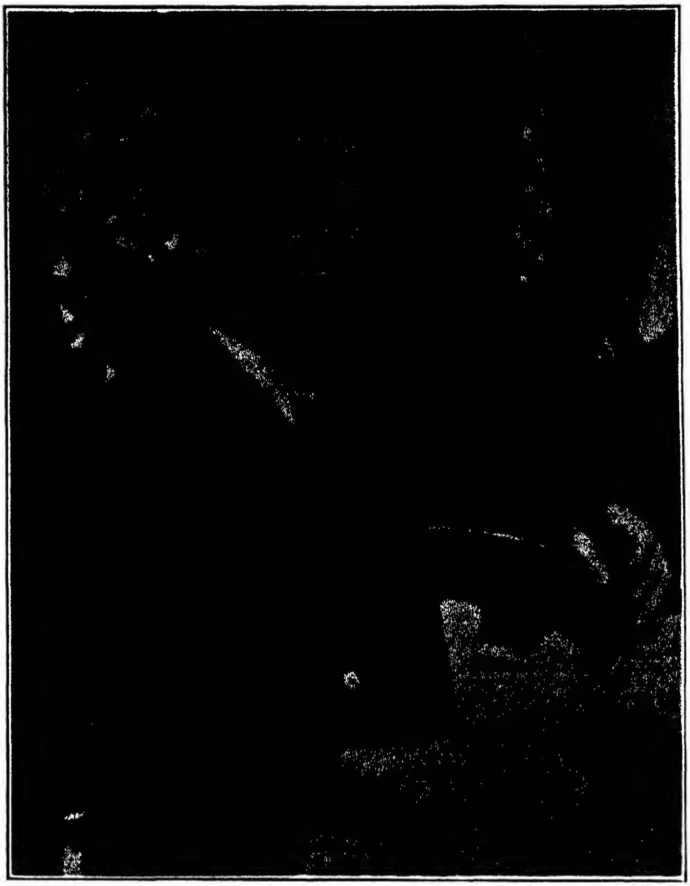
During the greater part of 1902, Koebele was studying the insects affecting lantana in Mexico, and sending to Honolulu those which he found to be particularly attached to lantana and not likely to become injurious to any other plants. At that time, Dr. R. C. L. Perkins was employed by the Territory and assisted

Koebele in his work. The parasite material sent by Koebele was taken care of by Perkins and liberations made in favorable places for them to become established, at the same time destroying parasites, many of which affected most of the insects which it was desired to introduce. The enemies to lantana which were successfully introduced were as follows: Two butterflies, *Thecla echion* Linn. and *Thecla agra* Hew., whose larvae feed on lantana flowers; two moths, *Crocidosema lantanae* Busck. and *Platyptilia pusillidactyla* Walker, whose larvae destroy the lantana flower clusters; a leaf-miner, *Cremastobombycia lantanella* Busck. whose larvae feed inside the leaves; a leaf-bug, *Teleonemia lantanae* Dist., the young of which feed so numerously on the under side of the leaves as to destroy them and check the new growth of the plant sufficiently as to prevent flowering; a stem gall-fly, *Eutreta xanthochaeta* Ald., whose larvae live in enlargements of the freshly growing stems; a seed-fly, *Agromyza lantanae* Frogg., whose larvae feed in the fruits, often destroying the seeds, and usually causing the fruits to dry up, so that they are not eaten by birds with the resultant scattering of seeds. The combined results of the work of these eight introduced insects is to greatly reduce the enormous production of seeds that formerly occurred on lantana and which were so widely dispersed by the ripened fruits being eaten by birds.

During the summer of 1903, Koebele investigated leafhopper parasites in Ohio, where the writer had published a note on a dryinid parasite of a leafhopper occurring in grass lands of that region. He sent many hundreds of these parasites, and other leafhopper parasites that he discovered, to Hawaii to be tried on the sugar cane leafhopper which at that time was becoming very destructive on many of the sugar plantations. All of these Ohio parasites failed, and in the early summer of 1904, with Perkins, Koebele went to Australia in search of leafhopper enemies. Many were discovered in Queensland and attempts made at their introduction. The only successful introductions were four egg-parasites, the most important of which was *Paranagrus optabilis* Perkins, the second in importance being *Ootetrastichus beatus* Perkins, which was secured in Fiji, where Koebele stopped a short time on the return from this trip. The work of these egg-parasites resulted in greatly checking the leafhopper pest so that it was no longer a menace to the sugar industry. Another introduction at this time was *Aphanomerus pusillus* Perk., an egg-parasite on the torpedo-bug *Siphanta acuta* Walker, which was a pest on coffee, citrus and other garden and ornamental trees.

When he returned from Fiji, a short time was spent in Honolulu in the summer of 1905, which was the last time Koebele was in Honolulu. He went to California shortly afterward, and at different times in 1906-8 attention was given to the study of sugar cane insects and their parasites in Mexico and to the enemies of hornfly in Mexico and Arizona. A number of minor introductions were made. Those that succeeded were: *Eucoila impatiens* Say from Arizona in 1906, a parasite on dipterous larvae in cow dung; *Azya luteipes Muls.* from Mexico in 1908, a lady beetle feeding on Lecanium scales; *Hyperaspis jocosa* (Muls.), from Mexico in 1908, a lady beetle feeding on *Orthezia insignia* Douglas.

The latter part of 1908, Koebele went to Waldkirch, Germany, his boyhood home, where he was born in 1852. This was mainly as an opportunity for the recovery of his health which had been greatly impaired by so much time spent



ALBERT KOEBELE
Enlargement from a family group taken at his former home in Germany, earlier than the preceding photograph. (Courtesy of W. M. Giffard.)

in entomological exploration and research work in fever-infested regions of the tropics. While there during the summers of 1909-11, he studied the enemies of hornfly, and sent much material to Honolulu, but little, if any, success was obtained by this. In 1910, on account of continued failing health, he was relieved from active duty, though still retained as Consulting Entomologist by the H. S. P. A. He continued living in Germany and was there during the Great War, on account of which he was reduced to very meager circumstances and both he and his wife suffered great hardships. At the close of the war, as soon as it was learned of their circumstances, attempts were made by the Hawaiian Sugar Planters' Association to arrange for their return to their home in Alameda, California. By the time that all arrangements were completed, however, he had become too feeble for undertaking such a trip. He continued to fail and his death finally occurred December 28, 1924, in his 73rd year.

The services rendered by Mr. Koebele and the benefits derived by the agricultural and horticultural interests of Hawaii by his introduction of beneficial insects cannot be estimated in dollars and cents. He made the beginning in this line of work, and much of the time was working alone, yet seventeen species of ladybeetles were successfully introduced by him and have become valuable factors in keeping reduced such pests as scale insects, mealybugs, plant lice and leaf-mites. At least six other ladybeetles were introduced and became established, but after a few years disappeared. The eight lantana insects were introduced by him, and about the same number of miscellaneous parasites of Diptera, Lepidoptera, etc. Following Koebele in this line of work, the other entomologists have introduced a larger number of beneficial insects and some of them have produced more valuable results, but this should not in any way lessen the credit to be given to him who was the pioneer in Hawaii in this important phase of entomological work.

Papers and reports by Koebele or concerning his Hawaiian work were published as follows:

Report of a trip to Australia to investigate the natural enemies of the fluted scale. U. S. D. A., Ent. Bul. 21, 1890.*

Studies of parasitic and predaceous insects in New Zealand, Australia and adjacent Islands.* U. S. Dept. of Agriculture, pp. 1-39, 1893.

Professor Koebele and his work. Planters' Monthly, XV, p. 103, 1896.

Report on insect pests. Planters' Monthly, XV, pp. 590-598, 1896.

Report of the entomologist of the Hawaiian government. Planters' Monthly, XVI, pp. 65-85, 1897.

Report of Professor Albert Koebele, entomologist of the Hawaiian government. Planters' Monthly, XVII, pp. 208-219, 258-269, 1898.

Report of Professor Albert Koebele, entomologist. Report of the Com. of Agr. and Forestry for 1900, pp. 36-49, 1901. Also in Planters' Monthly, XX, pp. 299-309, 1901.

Report of Professor Koebele on destruction of forest trees, Hawaii. Rept. of the Com. Agr. and Forestry, Hawaii, for 1900, pp. 50-60, 1901.

Notes on insects affecting the Koa trees at Haiku forest on Maui. Rept. of the Com. Agr. and Forestry, Hawaii, for 1900, pp. 61-66, 1901.

Report of Professor Koebele on Lantana scale. Rept. of the Com. Agr. and Forestry, Hawaii, for 1901-02, pp. 54-65, 1903.

Report of Professor Albert Koebele. Third Report of the Board of Com. of Agr. and Forestry, Hawaii, for 1906, pp. 159-164, 1907.

Insect investigations in Mexico. Fourth Rept. Board of Com. of Agr. and Forestry, Hawaii, pp. 89-97, 1908.

Report on the enemies of *Lantana camara* in Mexico, and their introduction into the Hawaiian Islands. Ent. Bul. No. 16, Exp. Station, H. S. P. A., pp. 54-71, 1923.

* This paper is concerned with Koebele's work before coming to Hawaii, but the knowledge gained thus was of great assistance when he began here, and deals with the same species as many of his early introductions to Hawaii.

Records of Introduction of Beneficial Insects Into the Hawaiian Islands

By O. H. Swezey

Apparently the first beneficial insect purposely introduced into Hawaii was the ladybeetle (*Novius cardinalis* Muls.), which is an enemy of the cottony cushion scale (*Icerya purchasi* Mask.). This was introduced from Australia in 1890 (probably via California) by Mr. Albert Koebele, who was engaged at that time in introducing beneficial insects into California to attack their orchard pests.

Since that time, there have been many species of beneficial insects successfully introduced into Hawaii, from various parts of the world, and by several institutions here. Mr. Koebele was engaged for this work in 1893. Between that time and 1904 many valuable ladybeetles were introduced, also parasites of scale insects. In 1904 the Experiment Station of the Hawaiian Sugar Planters' Association began introducing parasites for the sugar cane leafhopper, and has continued the work of introducing beneficial insects for one insect pest or another ever since. The Territorial Board of Agriculture and Forestry has also been active in this line of work; the United States Experiment Station and the Honolulu office of the United States Bureau of Entomology have also had a share in this important work.

The records of these introductions are very scattered, and in some cases very obscure, possibly entirely lacking in many cases. Herewith an attempt is made to put together for convenient reference the records of all successful introductions, so far as they could be found. They are grouped according to the various purposes for which they were introduced. The date of introduction is given, so far as known, the country from which introduced, and the particular pest on which it preys.

At the time when these various insects were being introduced, many others were experimented with, perhaps ten times as many as are included in this list. Some of these, for one reason, and some for another, have failed to become established. Possibly there are others of them that did succeed in becoming established, but not in sufficient abundance for them to come to our notice. In any such cases, of course, very little benefit could be derived from them. The majority of those listed have been of great benefit, and in some cases their particular host pests are entirely under control.

Ladybeetles Preying on Scale Insects, Mealybugs, Etc.

1890. *Novius cardinalis* Muls. From Australia via California. On cottony cushion scale.

? [1] *Novius koebelei*. From Australia via California. On cottony cushion scale.

[1] Abundant in 1897, but later disappeared.

1894. *Cryptolaemus montrouzieri* Muls. From Australia via California. ? On mealybugs.
1894. [2] *Rhizobius ventralis* Erich. From Australia via California. On mealybugs.
? [1] *Cryptogonus orbiculus* (Gyll.). Japan. On mealybugs.
1895, 1906, 1914. *Nephus* sp. near *bipunctatus* Kugel. Japan, South China, Philippines. On mealybugs.
1894. *Orcus chalybaeus* (Boisd.). Australia. Diaspine scales.
1894. *Serangium maculigerum* Blkb. Australia. Diaspine scales.
? *Lindorus lophanthae* Blaisd. California. Diaspine scales.
1895. *Chilocorus circumdatus* Schon. South China. Diaspine scales.
1895. *Sticholotis punctatus* Crotch. China, Japan. Diaspine scales.
1895. [3] *Pentilia nigra* Weise. China, Japan. Diaspine scales.
1908. *Azya luteipes* Muls. Mexico. Lecaniinae.
1908. *Hyperaspis jocosa* (Muls.). Mexico. *Orthezia.*
1922. *Curinus coeruleus* Muls. Mexico. *Pseudococcus nipae.*
1922. *Hyperasps silvestrii* Weise. Mexico. *Pseudococcus nipae.*
1922. *Nephus* sp. Mexico. *Pseudococcus bromeliae.*
1922. *Diomus* sp. Mexico. Mealybugs.
1922. *Diomus* sp. (four-lined). Mexico. Mealybugs.

Coccid Parasites

1894. ? *Aspidiotiphagus citrinus* Craw. China, Japan. On diaspine scales.
1905. *Scutellista cyanea* Motsch. California. *Saissetia nigra.*
1908. [4] *Comperiella bifasciata* How. Japan. Diaspine scales.
1915. *Leptomastidea abnormis* (Gir.). Sicily via California. *Pseudococcus kraunhiae.*
1922. *Pseudaphycus utilis* Timb. Mexico. *Pseudococcus nipae.*
1922. *Coelaspidia osborni* Timb. Mexico. *Pseudococcus calceolariae.*

It is probable that many of the other parasites established in the Hawaiian Islands on introduced Coccids are some of those that were purposely introduced, but on account of their identity not being known at the time of introduction definite records are lacking.

Ladybeetles Preying on Plant Lice

1893. [5] *Coccinella californica* Mann. California. (Disappeared after 1896.)
1894. *Coelophora inaequalis* (Fab.). Australia, Ceylon, China.
1894. *Platyomus lividigaster* Muls. Australia.
1894. *Diomus notescens* (Blkb.). Australia.

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[1] Abundant in 1897, but later disappeared.

[2] The ladybeetle introduced under this name, and for a long time considered as such, has recently been shown by Mr. Timberlake to be a species of *Lindorus.*

[3] Recorded as introduced, but this name is used by ~~Koebele~~ incorrectly, and the species supposedly introduced, although established, is as yet undetermined.

[4] Doubtfully established.

[5] Again introduced in 1905, but failed.

1895. *Coelophora pupillata* (Schon.). Hongkong.

Before 1894. [6] *Callineda conformis* (Boisd.). Australia. (Disappeared after 1906.)

1895. *Synonyche grandis* Thun. China, Japan. (Disappeared after 1896.)

1895. *Verania discolor* Fab. Hongkong. (Disappeared after 1896.)

1895. *Coelophora biplagiata* Swartz. Hongkong. (Disappeared after 1896.)

Scymnus, several undetermined species introduced; details of introduction not known.

Other Enemies of Plant Lice

Syrphid flies and Chrysopid flies were reported established by Koebele in 1897. It is not known which species, nor where from, nor when introduced.

1904. *Chrysopa* sp. Australia.

1907. *Trioxys* sp. ? California. Parasite on orange Aphis.

1919. *Micromus vinaceus* Gerst. Queensland.

1923. *Lysiphlebus testaceipes* (Cress.). California.

Enemies of the Sugar Cane Leafhopper

1904. *Paranagrus optabilis* Perkins. Queensland. Egg-parasite.

1904. *Paranagrus perforator* Perkins. Queensland. Egg-parasite.

1904. *Anagrus frequens* Perkins. Queensland. Egg-parasite.

1905. *Ootetrastichus beatus* Perkins. Fiji. Egg-parasite.

1906. *Haplogonatopus vitiensis* Perkins. Fiji. Parasite on nymph.

1907. *Pseudogonatopus hospes* Perkins. China. Parasite on adult.

1916. *Ootetrastichus formosanus* Timb. Formosa. Egg-parasite.

1920. *Cyrtorhinus mundulus* (Bredd.). Queensland and Fiji. Predacious on eggs.

Bruchid Parasites

1910. *Uscana semifumipennis* Gir. Texas. Egg-parasite.

1910. *Heterospilus prosopidis* Vier. Texas. Parasite on larva.

1921. *Lariophagus texanus* Cwfd. Texas. Parasite on larva.

1921. *Urosigalphus bruchi* Cwfd. Texas. Parasite on larva.

1921. *Glyptocolastes bruchivorus* Cwfd. Texas. Parasite on larva.

1921. *Horismenus* sp. Texas. Parasite on larva.

Fruit-Fly Parasites

1913. *Opius humilis* Silv. South Africa. On larva of *Ceratitis capitata*.

1913. *Diachasma tryoni* Cam. Australia. On larva of *Ceratitis capitata*.

1914. *Diachasma fullawayi* Silv. Africa. On larva of *Ceratitis capitata*.

1914. *Tetrastichus giffardianus* Silv. West Africa. On larva of *Ceratitis capitata*.

1913. *Dirhinus giffardii* Silv. West Africa. On pupa of *Ceratitis capitata*.

[6] Again introduced in 1904, but failed.

1913. [7] *Galesus silvestrii* Kieffer. West Africa. On pupa of *Ceratitis capitata.*
1916. *Opius fletcheri* Silv. India. On larva of *Bactrocera cucurbitae.*

Other Enemies of Diptera

1906. *Eucoila impatiens* Say. Arizona. On larva of *Sarcophaga.*
1909. [7] *Bathymetis* sp. Germany. On puparium of horn-fly.
1909. *Hister bimaculatus* L. Germany. Predacious on maggots.
1913. *Muscidifurax raptor* Gir. & Sand. South Africa. Parasite on puparia.
1914. *Pachycrepoideus dubius* Ashm. Philippines. Parasite on puparia.
1914. *Spalangia philippinensis* Ful. Philippines. Parasite on puparia.
1914. *Spalangia* sp. Africa. Parasite on puparia.
1921. *Creophilus erythrocephalus* Fab. Australia. Predacious on maggots.

Parasites of Leafrollers and Armyworms

1895. *Microbracon omiodivorum* (Terry). Japan. On larva of leafrollers.
1895. *Chalcis obscurata* Walker. Japan. On pupa of leafrollers, etc.
? *Amblyteles koebelei* (Sw.). California. Armyworm parasite.
? *Amblyteles purpuripennis* (Cress.). California. Armyworm parasite.
? *Frontina archippivora* Will. North America. Armyworm parasite.
1923. *Euplectrus platyhypenae* How. Mexico. Armyworm parasite.
1924. *Archytas* sp. Mexico. Armyworm parasite.

Miscellaneous

1904. *Aphanomerus pusillus* Perk. Queensland. Egg-parasite of *Siphanta acuta.*
1909. *Blastophaga psenes* (Linn.). California. Caprifier of edible fig.
1910. *Ceromasia sphenophori* Vill. New Guinea. Parasite of larva of *Rhabdocnemis obscura.*
1916. *Paranagrus osborni* Ful. Philippines. Egg-parasite of corn leafhopper.
1916. *Scolia manilae* Ashm. Philippines. Parasite of larva of *Anomala* and *Adoretus.*
1917. *Dolichurus stantoni* Ashm. Philippines. Parasite on nymph of roach.
1921. *Ischiogonus syagrii* Ful. Australia. Parasite of larva of Australian fern weevil.
1921. *Pleistodontes froggatti* Mayr. Australia. Caprifier of *Ficus macrophylla.*
1922. *Pleistodontes imperialis* Saund. Australia. Caprifier of *Ficus rubiginosa.*
1922. *Notogonidea luzonensis* Rohwer. Philippines. Parasite of field cricket.
? *Stethorus vagans* Blackburn. Predacious on leaf-mites.
1922, 1925. *Bactra truculenta* Meyr. Philippines. Borer in nut grass.

Lantana Insects

1902. *Agromyza lantanae* Frogg. Mexico. Larvae in seeds.
1902. *Thecla echion* Linn. Mexico. Larvae on flowers.
1902. *Thecla agra* Hew. Mexico. Larvae on flowers.

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[7] Doubtfully established.

1902. *Crocidosema lantana* Busck. Mexico. Larvae in flower clusters.
1902. *Platyptilia pusillidactyla* Walk. Mexico. Larvae in flower clusters.
1902. *Cremastobombycia lantanella* Busck. Mexico. Leafminer.
1902. *Teleonemia lantanae* Distant. Mexico. Leaf-bug.
1902. *Eutreta xanthochaeta* Aldrich. Mexico. Stem gall-fly.

INTRODUCED INSECTS WHICH FAILED TO BECOME ESTABLISHED

Among the large number of beneficial insects whose introduction has been attempted in Hawaii, by far the larger number have failed. It is impossible to give a complete list of all of these, as for many of them no records were kept, especially as in many cases their identity was not known, and since they failed to become established no attempt was made at determining them. In the lists as here given those are included that are not as yet known to have become established, although they may yet be found established later on. Sometimes an introduced insect has not been recovered for several years after its introduction. Then, too, some may be included which became established at first but have disappeared and have not been recovered in more recent years. Some are of too recent introduction for their establishment to be known as yet.

These lists are grouped according to their hosts, or the purpose for which they were desired.

Introduced Ladybeetles that Failed

Ladybeetles	Locality	Host
1891. * *Chilocorus bivulnerus* Muls.	California	*Lecanium*, etc.
1893, 1906. *Hyperaspis postica* Lec.	California	Mealybugs
1893. *Hyperaspis depressa* Casey	California	Mealybugs
1893. *Hyperaspidius comparatus* Casey	California	Mealybugs
1893. *Scymnus* sp.	California	Mealybugs
1894. † *Hyperaspis undulata* Say	California	Mealybugs
1895, 1906. *Rhodolia fumida* Muls.	China	*Icerya purchasi*
1895. *Rhodolia pumila* Weise	China	*Icerya purchasi*
1895. *Synonyche grandis* Thun.	China	Plant lice
1895. *Verania discolor* Fab.	Hongkong	Plant lice
1895, 1905. *Chilocorus similis* Rossi	Japan	Scale insects
1895. *Hyperaspis japonica* (Crotch)	Japan	Mealybugs
1896, 1905, 1910. *Hippodamia convergens* Guer.	California	Plant lice
1896. *Cycloneda sanguinea* Linn.	California	Plant lice
1896, 1902, 1906, 1908. *Chilocorus cacti* Linn.	California and Mexico	Scale insects
1896, 1902, 1906. *Hyperaspis lateralis* Muls.	California and Mexico	Mealybugs

*** This species was again introduced in 1894. It was found breeding in 1896, but later disappeared.**

† Several species of *Hyperaspis* and large quantities of other California ladybeetles were introduced in 1894. *H. undulata* was observed 10 months later. None of them found since.

1896.	*Psyllobora taedata* Lec.	California	*Oidium*
1899.	*Anisorcus affinis* Crotch	Fiji	Scale insects
1904.	*Neda testudinaria* Muls.	Australia	Plant lice and young leafhoppers
1904, 1906.	*Verania lineola* (Fab.)	Australia and Fiji	Plant lice and young leafhoppers
1904.	*Verania frenata* (Erich.)	Australia	Plant lice and young leafhoppers
1904.	*Orcus cyanocephalus* Muls.	Australia	Plant lice and young leafhoppers
1904.	*Orcus bilunulatus* (Boisd.)	Australia	Plant lice and young leafhoppers
1904.	*Orcus lafertei* Muls.	Australia	*Pseudococcus nipae?*
1904.	*Platyomus koebelei* Blkb.	Australia	Coccidae
1905.	*Hippodamia ambigua* Lec.	California	
1905.	*Coccinella californica* Mann.	California	
1906.	*Archaioneda tricolor* var. *fijiensis* Crotch	Fiji	Plant lice and young leafhoppers
1906.	Reddish yellow ladybeetle	China	
1906.	*Exochomus pilatei* Muls.	Arizona	Avocado mealybugs
1906.	*Exochomus marginipennis* Lec.	Arizona	Avocado mealybugs
1906.	*Hyperaspis limbatus* Casey	California	Mealybugs
1906.	*Thalassa montezumae* Muls.	Arizona	Lecaniid
1907.	*Hyperaspis 8-notata* Casey	Mexico	Avocado mealybug
1909.	*Adalia bipunctata* L.	Germany	Plant lice
1909.	*Coccinella septempunctata* L.	Germany	Plant lice
1911.	*Coccinella bipunctata* L.	Germany	Plant lice
√ 1913.	*Coccinella bruckii* Muls.	Japan	Plant lice
1919.	*Coccinella arcuata* Fab.	Australia	Plant lice
1919.	*Coccinella repanda* Thunb.	Australia	Plant lice
1924.	Several ladybeetles	Canal Zone	Pineapple mealybug

Other Scale Enemies

1904.	Chalcid	Australia	Mealybugs
1904.	*Thalpochares* sp.	Australia	*Eriococcus*
1906.	Chalcid	Arizona	Mealybugs
1910.	Chalcids	Germany	Coccids
1924.	Chalcids	Canal Zone	Pineapple mealybug

Introduced Leafhopper Enemies that Failed to Become Established

1903.	Several dryinids	Ohio and California	Parasites on young
1903.	*Anagrus columbi* Perk.	Ohio	Egg parasite
1904.	*Epipyrops,* several species	Australia	Predacious
1904.	Earwigs	Australia	Predacious
1904.	Several dryinids	Australia	Parasites on young
1905.	Stylopid	Fiji	Parasite
1916.	*Ootetrastichus* sp.	Formosa	Egg parasite
1919.	*Drypta australis* Dej.	Queensland	Predacious
1919.	*Drypta,* 2 other species	Queensland	Predacious
1919.	*Paederus* sp.	Queensland	Predacious

Anomala and Adoretus Enemies that Failed

1896. *Sarcophaga* sp.	Mexico	Parasite on Scarabaeid beetle
1913, 1916. *Tiphia* sp.	Japan	Parasite on grub
1915-16. *Craspedonotus tibialis* Schaum	Japan	Predacious
1916. *Tiphia lucida* Ashm.	Philippines	Parasite on grub
1916. *Tiphia segregata* Crawf.	Philippines	Parasite on grub
1916. *Tiphia ashmeadi* Crawf.	Philippines	Parasite on grub
1916. *Prosena* sp.	Philippines	Parasite of grub
1916. *Dexia* sp.	Philippines	Parasite of grub

Enemies of Armyworms and Cutworms that Failed

1896, 1906. *Tetracha carolina* Linn.	Mexico, Arizona	Predator
1896. *Omus californicus* Esch.	California	Predacious beetle
1896. *Cychrus cristus* Harr.	California	Predacious beetle
1896. *Cychrus interruptus* Min.	California	Predacious beetle
1896. *Cychrus striatopunctatus* Chd.	California	Predacious beetle
1896. *Calosoma*, 5 species	Mexico	Predacious beetle
1896. *Pasimachus tolucanus* Chd.	Mexico	Predacious beetle
1902. *Microgaster* sp.	Mexico	Internal parasite
1902. Braconid ?	Mexico	External parasite
1902. *Euplectrus* sp.	Mexico	External parasite
1906. *Calosoma simplex* Lec.	Arizona	Predator
1906. *Calosoma*, other species	Arizona	Predator
1919. *Chlaenius* sp.	Australia	Predator
1924. *Apanteles militaris* (Walsh)	Mexico	Parasite

Enemies of Hornfly and Other Dipterous Maggots that Failed

1898. *Hister* sp.	Mexico	Predacious
1902. Dung beetles	Mexico	
1902, 1904. Dung beetles	Australia	
1905. Dung beetles	Australia	
1905. Braconid	Australia	Parasite
1906. *Eutrias* sp.	Arizona	
1906. Histerids	Arizona	
1906, 1922. *Pinotus colonicus* (Say)	Arizona and Mexico	
1906. Dung beetles, 6 species	Arizona	
1908. *Philonthus aeneus* Rossi	Germany	Predacious
1908. *Spalangia* sp.	Germany	Parasite
1908-12. *Figites* sp.	Germany	Parasite
1909. *Sphaeridium scarabaeoides* L.	Germany	Predacious
1909. *Aphodius fimetarius* (L.)	Germany	
1909-10. *Atractodes* sp.	Germany	Parasite
1909-10. *Alysia* sp.	Germany	Parasite
1910. Small Staphylinids	Germany	Predacious
1910. Small Hydrophilids	Germany	Predacious
1910. *Onthophagus nuchicornus* (L.)	Germany	
1911. *Polietes lardaria* Fab.	Germany	Predacious maggots
1914. Staphylinid beetles	N. Africa	Predacious
1919, 1922. *Onthophagus* sp.	Australia	
1921. *Onthophagus* sp.	Philippines	
1922. Several kinds of dung beetles	Mexico	

Miscellaneous

1905.	Leafhopper	Australia	On dodder (*Cuscuta*)
1907.	Histerid	Java	Predacious on cane borer
1908.	Elaterid	Amboina	Predacious on cane borer
1908.	Histerid	Amboina	Predacious on cane borer
1910.	*Pimpla behrenzii* Cress.	California	Parasite on leafrollers
1910.	*Chalcis ovata* Say	California	Parasite on leafrollers
1910, 1919.	*Pteromalus puparum* (Linn.)	California	On cabbage butterfly
1913.	*Aphidius* sp.	Japan	Parasite on plant lice
1913.	*Lysiphlebus* sp.	Japan	Parasite on plant lice
1916.	*Apanteles* sp.	Formosa	Parasite on pink bollworm
1919.	*Chelonus* sp.	Australia	Parasite on koa seed moth
1921, 1925.	Fig wasps for *Ficus retusa*	Hongkong	
1921, 1925.	*Larra luzonensis* Rohw.	Philippines	On mole cricket
1922.	*Larra* sp.	Philippines	On mole cricket
1922.	*Odynerus luzonensis* Rohw.	Philippines	On bean butterfly
1922.	Ichneumonid	Philippines	On bean butterfly
1922.	*Euplectrus* sp.	Philippines	On looping caterpillar
1922, 1925.	Curculionid	Philippines	Borer in nut grass
1923.	*Diaeretus* sp.	California	Parasite on Aphis
1923.	*Aphelinus* sp.	California	Parasite on Aphis
1923.	*Syrphus nitens* (Zetter)	California	Predacious on Aphis
1923.	*Syrphus opinator* O. S.	California	Predacious on Aphis
1923.	*Catabomba* sp.	California	Predacious on Aphis
1923.	*Eupeodes volucris* O. S.	California	Predacious on Aphis
1923.	*Scaeva pyrastri* (L.)	California	Predacious on Aphis
1923.	*Allograpta* sp.	California	Predacious on Aphis
1923.	*Myiophasia metallica* Towns.	Mexico	Parasite on cane borer
1923.	*Phanurus* sp.	Mexico	Egg-parasite of Zelus
1924.	*Podium haematogastrum* Spin.	Para, Brazil	Parasite of roach
1924.	*Larra*, 2 species	Para, Brazil	Parasite mole cricket

Lantana Insects Whose Introduction from Mexico was Attempted but Failed to Establish

1902. *Aerenicopsis championi* Bates. A Cerambycid beetle whose larva bores the stem.

1902. *Evander xanthomelas* Guer. A Cerambycid beetle whose larvae are borers in the base of stem and roots.

1902. *Apion* 2 sp. Curculionid beetles whose larvae feed in the seeds.

1902. Cecidomyiid fly whose larvae feed in flower galls.

1902. *Thecla pastor* Druce, and two other species of *Thecla* butterflies whose larvae feed on flowers.

1902. *Tephroclystis* sp. A Geometrid moth whose larvae feed on the flowers.

1902. *Hepialus* sp. A moth whose larva bores the stem.

1902. *Crocidosema* sp. A Tortricid moth whose larvae feed on flower heads and maturing seeds.

1902. *Octotoma scabripennis* Guer. A beetle whose larvae are leaf miners on lantana.

A Report on Mechanical Methods in Dusting Cane Fields

By H. Atherton Lee, J. P. Martin and Clyde C. Barnum

The use of fungicides in preventing fungus diseases of plants has been in use for almost a century. Such fungicides have chiefly been used in the form of liquid sprays and such liquid sprays in cane fields have never been feasible because of the large areas to be covered and the impassable condition of the crop after the cane is a few months old. On some crops liquid sprays have also been used to supply plant nutrients, as in the case of iron sulphate for pineapples and sodium nitrate, in one instance, on apples.

More recently, possibly within the last ten years, the use of fungicides in the form of dry dusts has been adopted for a number of garden and orchard crops. Several fungus diseases of plants have been very successfully held in check by such fungicidal dusts. With the increasing use of dust fungicides there has been a development of mechanical equipment for their application. This led to the

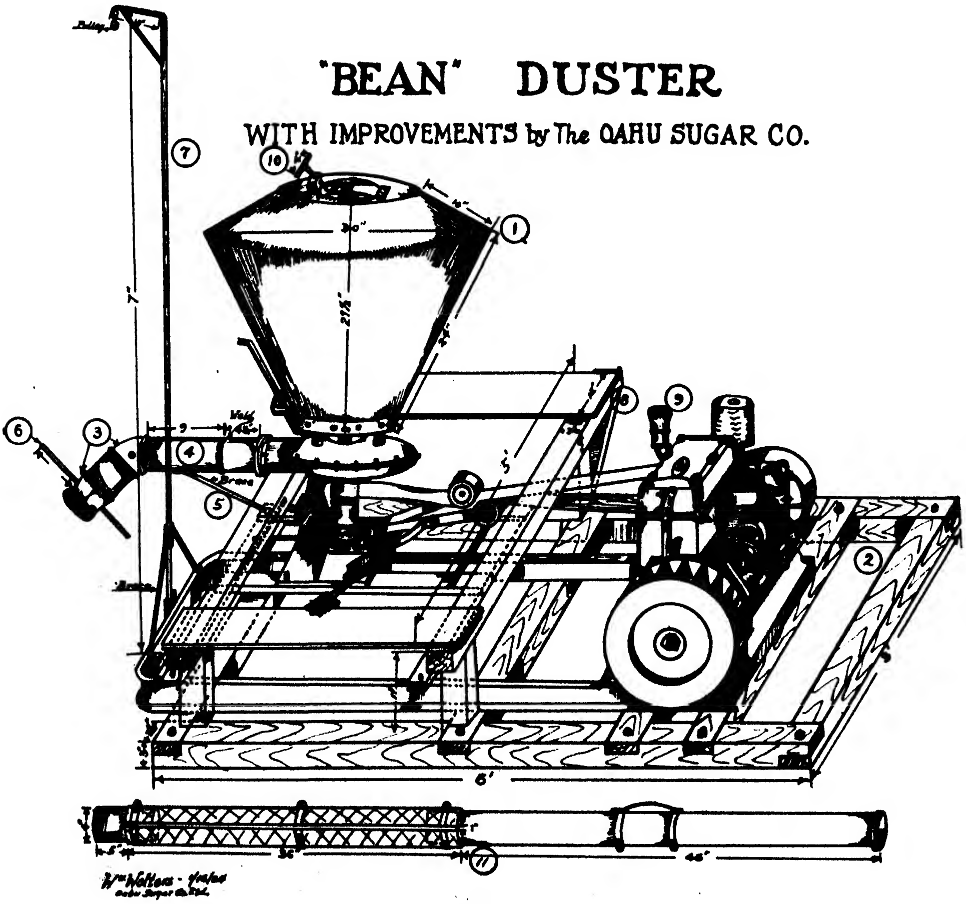


Fig. 1

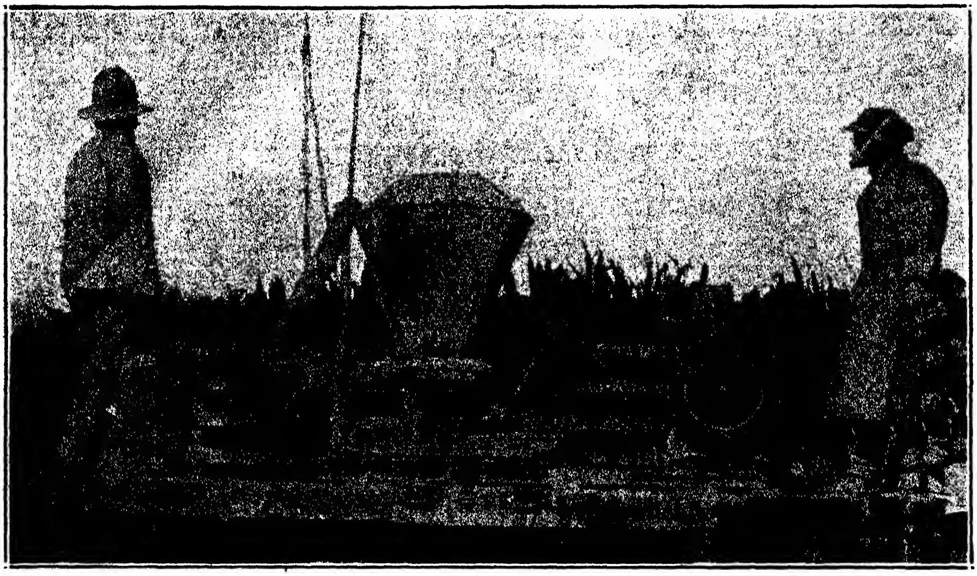


Fig. 2. Showing the dusting machine and engine mounted on a motor truck.

belief that possibly the same mechanical equipment, with modifications, could be used in applying dust fungicides over the large areas of the cane fields of the character found in these Islands for preventing fungus diseases.

The Nature of the Dusting Equipment

A dusting machine, manufactured by the Bean Spray Pump Company, of San Jose, California, was secured. It consists of a hopper which holds the dust and contains an agitator to prevent the dust from clogging, a horizontally placed fan which is driven at 2,500 revolutions per minute, and an outlet tube of about four inches in diameter and six feet in length. The fan and agitator are belt-driven by a four-horse-power engine.

It was our idea that this equipment could be mounted on a light motor truck or cane car and the dust applied from the edges of the field. It seemed possible, also that in the event of inability to reach all parts of a field a narrow cart drawn by a mule could be specially constructed to be driven along the level ditches. To the present time, however, such a cart has not been necessary.

Important modifications in the equipment have been made by W. A. Wolters, of the Oahu Sugar Company, which have greatly simplified the work and increased the efficiency of the duster. A drawing showing the machine with Wolters' large-sized hopper, oak platform, outlet-tube support and modified outlet is shown in Fig. 1. A photograph of the equipment is shown in Fig. 2.

The studies in the prevention of eye spot were divided into two projects, the first to test the mechanical ability of this equipment to economically place the dust on the large cane fields, which are usual in these Islands, and the second to test out various fungicidal dusts for their toxic effect upon the fungus which causes eye spot. This report covers the progress in the first of these projects

only; that is, the tests to determine the mechanical ability of the dusting equipment to place the fungicide in a satisfactory manner on the cane over the large areas of our cane fields affected with eye spot disease.

Methods of Dust Application

It was first found that winds are not an aid in placing the dust on the cane but that the apparently still air in the early morning hours is essential for the dust applications. In the hours between 5:30 and 8:30 A. M. there is usually no perceptible wind, although on putting a few puffs of the dust in the air the movement of the dust usually shows very slow air currents. Such air currents, moreover, are usually fairly uniform for each field, and with one or two early morning trials, experience is gained which can be followed throughout the rest of the season's applications.

Dew upon the leaves in the early morning hours is also an essential feature. The dust spreads upon coming in contact with the moisture and as the dew dries the film of moisture and partially dissolved dust form a close adherence with the leaf. Applications of dust under such conditions are entirely resistant to winds and mild rains, although beating rains wash off the film to a considerable extent.

Probably the most satisfactory evidence of the distribution of the dust over the cane is shown by the photographs in Figs. 3, 4, 5, 6 and 7. By the use of discretion in placing the dusting machines in reference to the air currents, the application of the dust on the cane has been successful beyond our expectations. In some fields the early morning air currents do not allow the dust to be placed on certain small areas. It is often possible in such instances to take advantage of the first northeast winds, which arise a few hours after sunrise, to reach these spots with the power duster. However, when such a change does not work to advantage, laborers with hand dusting machines, or machines on mules, can be advantageously used in such small areas.

Good organization of the work is also indispensable. There are usually but three or at most four hours in the early morning when the best results can be obtained. For this reason in order to cover large areas mechanical difficulties should be foreseen and avoided, supplies should be on hand and a schedule of fields and plan of the work be in mind before the beginning of the work. There are a number of small points which the truck drivers and the machine operators learn only by experience and it was found that inexperienced labor often cause losses of considerable periods of time. For this reason the same crews are used for the work throughout the season. An experienced crew consisting of a truck driver and two machine operators with a skilled employee to observe the placing of the dust and direct the crew is ample for the operation of the equipment. In time it would possibly be practical to dispense with the skilled employee.

Costs of Dusting

An approximate average of thirty acres a day has been dusted during the past season and a possibility of eighty to one hundred acres a day may be achieved with the machines equipped with the Wolters' modifications. Depend-

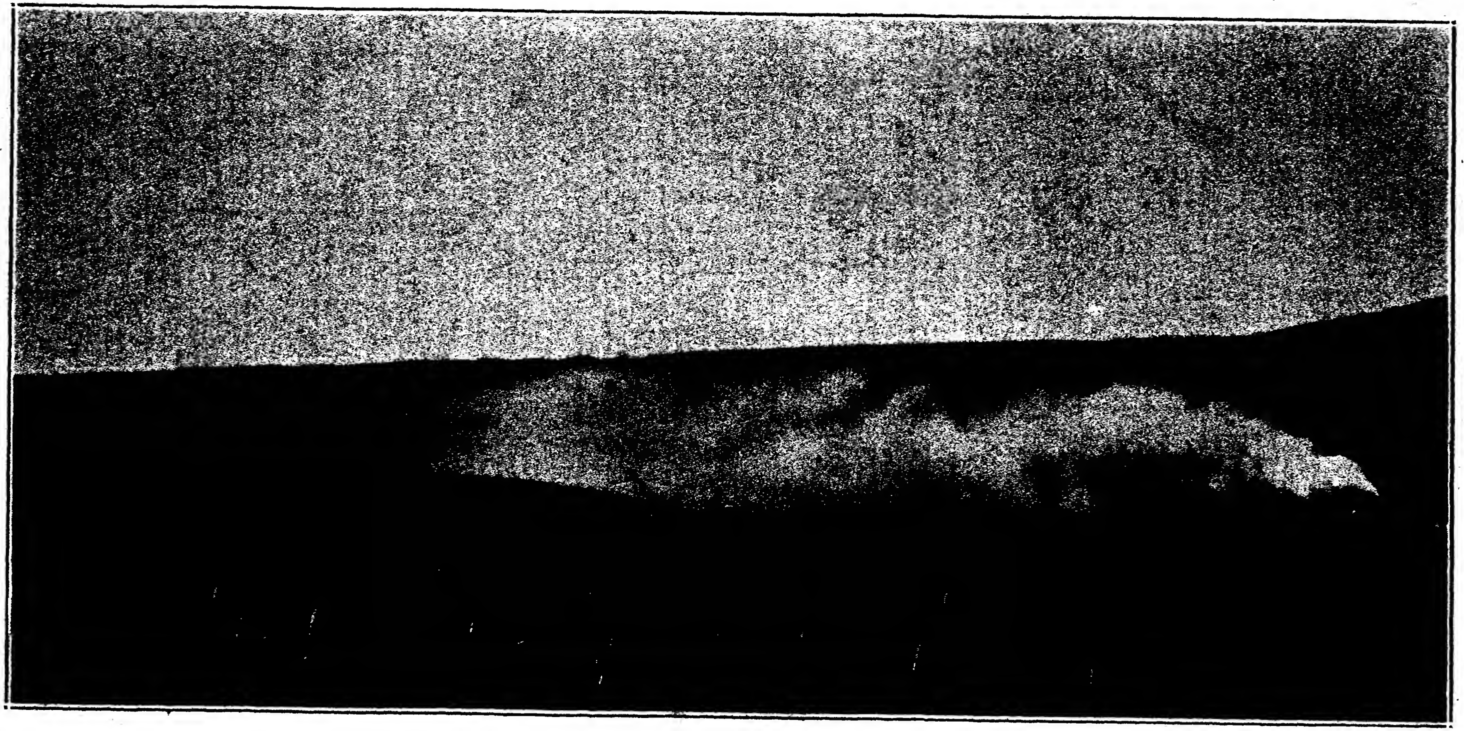


Fig. 3. Showing the extent of the distribution of the dust; note the dust disseminating itself in the lower reaches of the field. This is in Field 59 of the Oahu Sugar Company.

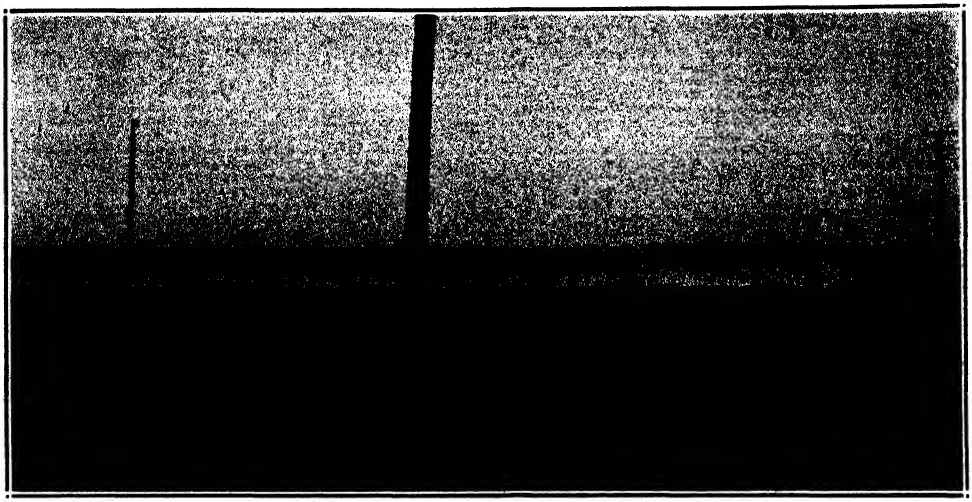


Fig. 4. Showing the extent of the distribution of the dust in the Mokuleia section at Waialua.

ing on the efficiency of the crew, the cost of labor and equipment in dusting has in the past varied between 35 and 50 cents per acre, exclusive of the cost of the dust. This cost can be greatly reduced with greater experience and efficiency. In the trial applications an average of 20 pounds of dust to the acre has been used at each application; the dust in use has cost 1.15 cents a pound. It is possible that with experience the amount per acre can be reduced and in large quantities the cost per pound can be reduced. The maximum cost per acre, therefore, is 23 cents for the dust and 50 cents for the labor, or 75 cents total cost; with high efficiency the cost may be brought down to a much smaller figure. Even at the maximum cost, twenty applications per year could be made profitably in some of the severely affected eye spot areas, although with favorable weather conditions in many seasons, only ten applications or less may be necessary.

The dust used against eye spot during the past season (1924-1925) was admittedly a very weak fungicide. We have dusts available for next season's work which are more satisfactory, but we feel that it may be possible to obtain a still more effective dust with further research.

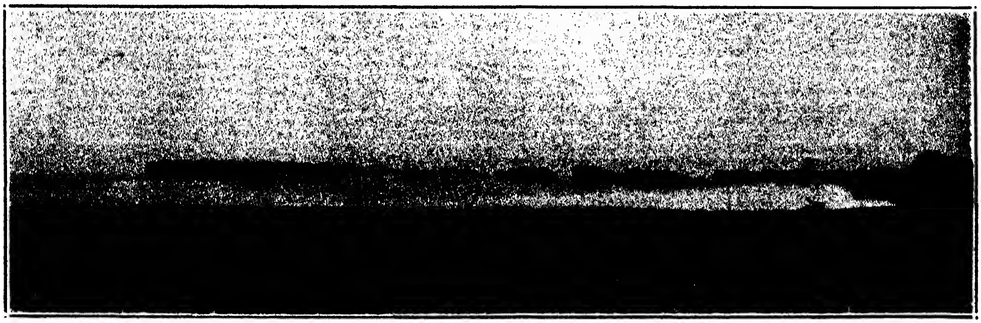


Fig. 5. Another view in the Mokuleia section at Waialua.

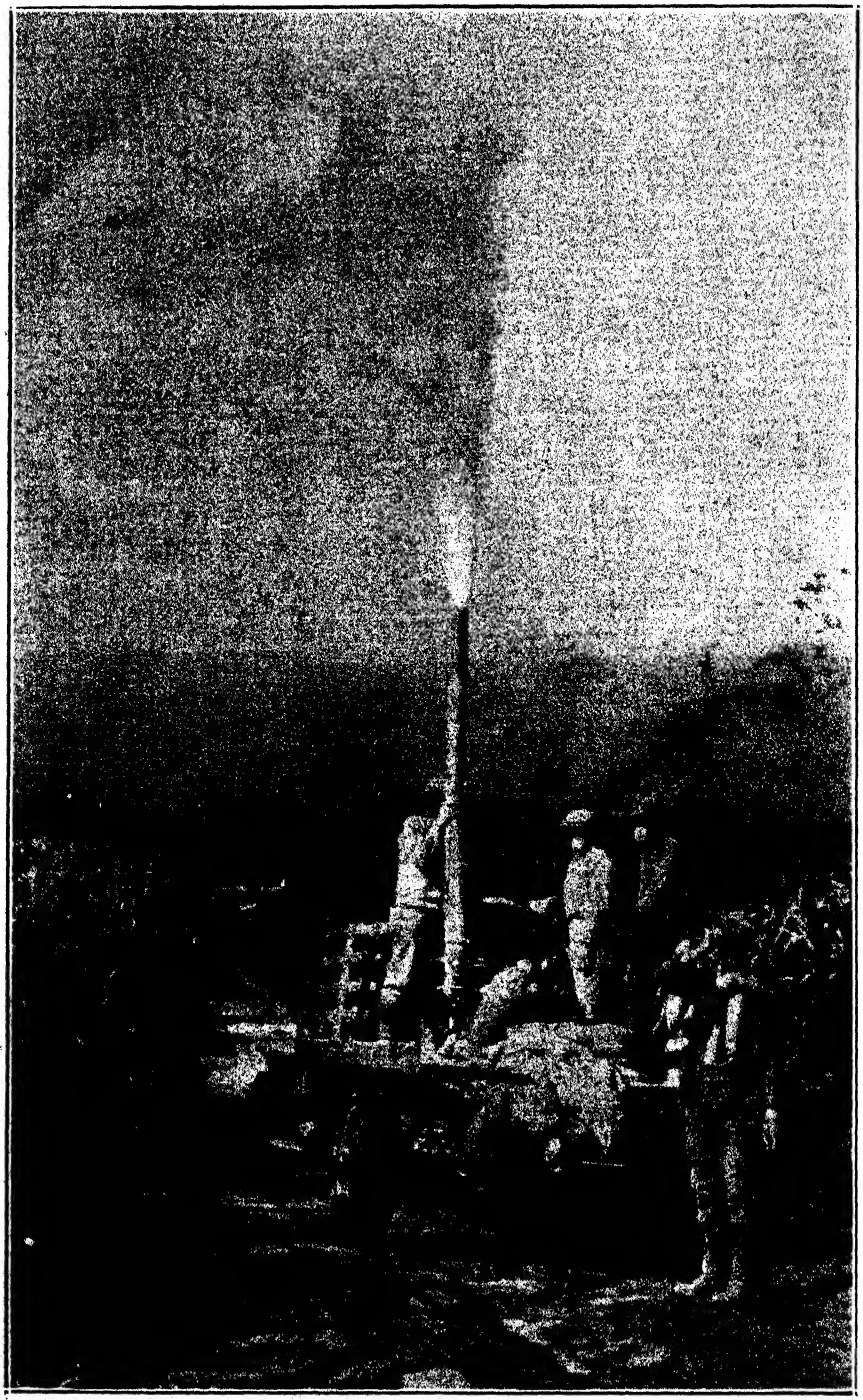


Fig. 6. A rear view of the apparatus and truck in operation at Waipahu.

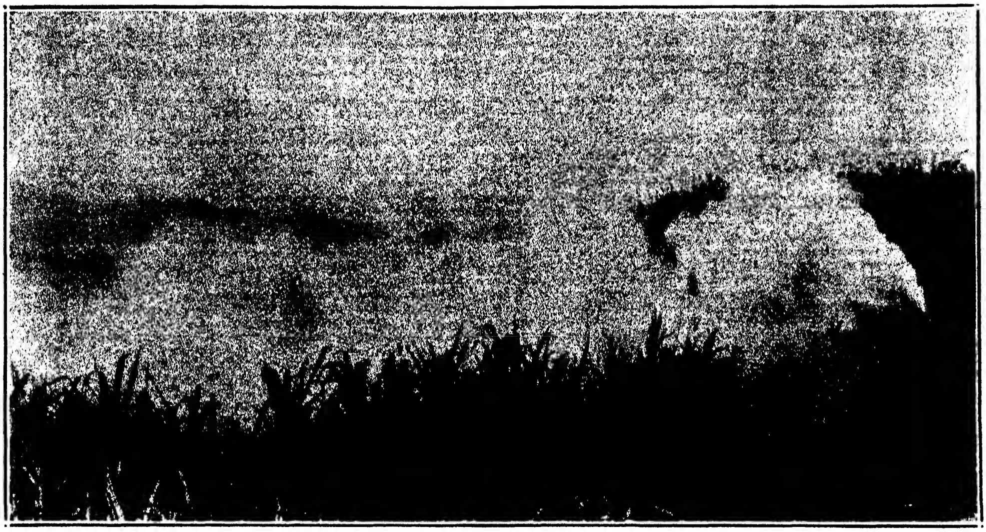


Fig. 7. Showing the way the dust penetrates and infiltrates through the cane, reaching not only the topmost leaves but practically all parts of the plant.

Our conclusions from the first season's experiments are: (1) that mechanically there is no difficulty in placing dust fungicides on any of our cane fields, and (2) that our dust mixture for last season was entirely too mild as a fungicide for eye spot and that a more effective dust is necessary.

Other Uses for Dusts

It has seemed to us that there may be other advantageous uses for these dusting methods. Other diseases may be attacked by dust applications. In the event of the introduction of a new infectious disease, disinfectant dusts could be used to minimize the spread of the infection until total eradication could be effected. If the dusting methods continue on to a successful plantation practice, it would seem that an added security to the industry against cane diseases is available.

The use of dusts in applying nutrients also comes to mind. Ballard in California obtained a very beneficial effect on apple trees by spraying with sodium nitrate. Other possibilities suggest themselves. With the ability to economically place materials on the aerial parts of cane plants a new field is opened for methods in increasing yields and lessening losses.

It has seemed possible to us that airplanes could be advantageously used; the use of airplanes would, possibly, secure a better distribution of the dust. A slightly increased cost per acre could be allowed and still be advantageous to obtain the surety of the uniformity of distribution by airplanes.

This work with the dusting machines has only been possible with the cooperation of the other members of the Experiment Station staff. H. P. Agee, the Director, particularly has aided the work administratively and with valuable suggestions. E. W. Greene, manager of the Oahu Sugar Company, has placed the

use of his machine shop at our disposal and with George F. Renton, Jr., and J. B. Thomson, has encouraged and supported the work. A good start has been made in making the dusting of cane fields an established plantation practice, although to be conservative, unforeseen natural difficulties may still be expected until the work has been successfully carried on for several years.

Irrigation Investigations at Waimanalo

By Guy R. Stewart

The first report on the cooperative irrigation investigations at Waimanalo appeared in the *Record* of April, 1924. The present report deals with the continuation of these studies. The period covered here is slightly over a year, being from December 1, 1923, to December 30, 1924. The work was continued on a cooperative basis between the Chemistry department of this Station and Waimanalo Sugar Company. William Weinrich conducted the field work until October, 1924, when it was taken over by T. K. Beveridge.

Lines of Work Undertaken

The following lines of work have received attention during the past year:

Irrigation Experiments,
Water Supply Studies,
Determination of Seepage Losses,
Measurement of the Distribution of Water to the Fields.

Irrigation Experiments

We continued the experiments in Fields 8, 22 and 15, the preliminary results of which were given in our report last year, and started an additional experiment in Field 4.

Harvesting Results, Fields 8 and 22:

The experiments in Fields 8 and 22 were harvested in the 1924 crop and a summary of the yields obtained is given in Table I:

TABLE I

Amounts of Water Applied and Yields Obtained in Irrigation Experiments 1924 Crop

Treatment	Field 8 Irrigation applied during experiment	Field 8 Yield in tons sugar per acre	Field 22 Irrigation applied during experiment	Field 22 Yield in tons sugar per acre
Crop Cane..........	17.17 in.	10.27	19.38 in.	6.13
Extra Irrigation....	53.13 in.	11.71	56.11 in.	6.95

It will be remembered that these experiments in Fields 8 and 22 were started with cane which was in its second season's growth, about 12 months of age. The period in which extra irrigation was applied was from July 1st to November 15, 1923. After this time the rainfall was sufficient for the further growth of the crop. When our work was first undertaken at Waimanalo we were especially asked to find whether additional irrigation water would give as good cane growth as is obtained on the better irrigated plantations. In these fields we were only able to start additional irrigation after the crop was well advanced in age. We cannot state therefore what result will be obtained if full irrigation were available for a field throughout its entire growth until our experiments in Field 15 are harvested this year.

The indication obtained from this experiment is that the rate of growth obtained by full irrigation at Waimanalo is as good as that obtained in the Pearl Harbor district. The amount of increased crop, in extra sugar, which we obtained by applying this additional water to 12 months old cane was not sufficient to make it economically profitable. In one case, in Field 15, a gain of 1.5 tons sugar was obtained; and in the other, in Field 22, about 0.8 ton sugar. While these increases are appreciable, if water is short, such gains will not pay for the large amount of additional water required.

Irrigation Experiments in Fields 15 and 4:

The results of the first season's observations upon the experiments in Field 15 were given in our last season's report. They may be briefly summarized by stating that the application of 25.6 inches of irrigation water to the extra irrigated cane, contrasted with 4.1 inches of water to the crop cane, gave 2.5 times as much length of growth of stick, or eight times the volume of stick, obtained on the crop cane. At the time of our report the difference in growth fully corresponded to the difference in the amount of water supplied. Later in the winter, during the period of the highest humidity, eye spot was very prevalent in this portion of the field. The extra irrigated cane proved to be particularly susceptible to this fungus growth. There was considerable injury from this eye spot, so that it is not certain that the same differences which were found last year still persist. There is still a notably larger growth in the extra irrigated cane, but the possibility of eye spot injury to fully irrigated H 109 cane is a consideration which must be kept in mind at Waimanalo. This experiment will be harvested in the 1925 crop, so the final yield results will soon be available.

The experiment in Field 4 was installed because this is a notably open, light type of soil which is much less retentive of water than the soil in Field 15. The cane is D 1135 which was planted late in the fall of 1923. The experimental plots were laid out December 20, 1923. This area will also be harvested in the 1925 crop.

Amount of Water Applied:

The irrigation water applied to both these irrigation experiments is summarized in Table II:

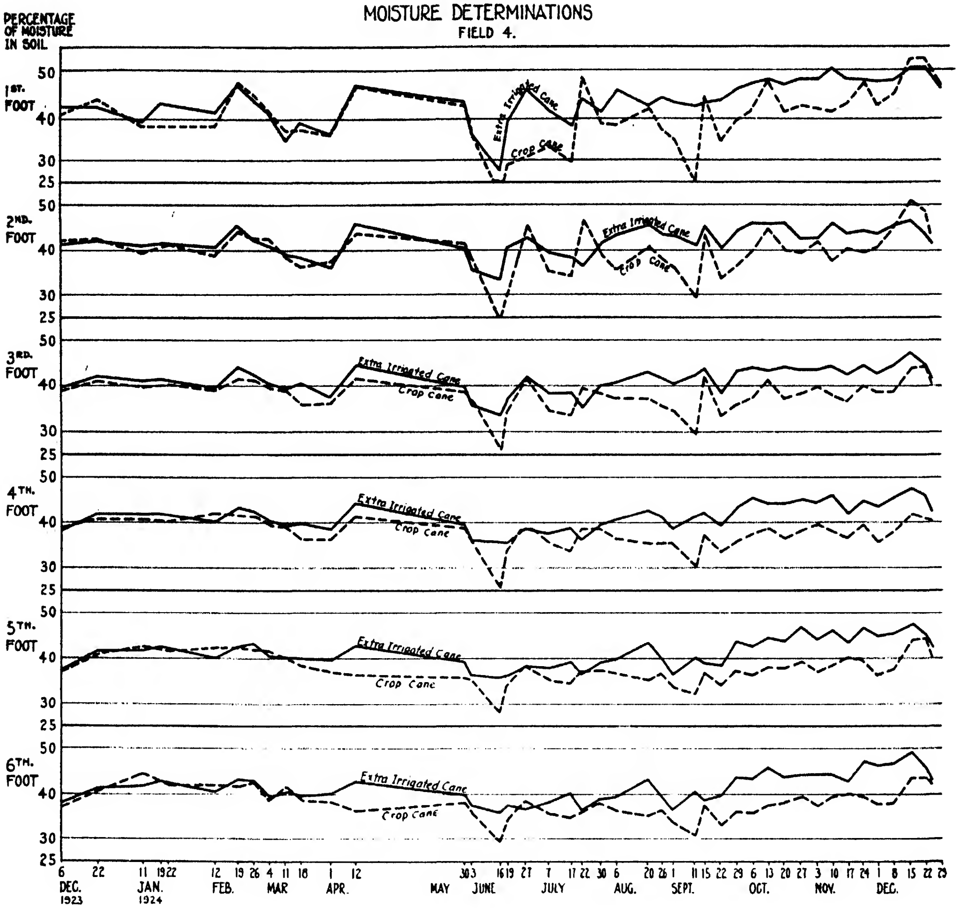
TABLE II

Summary of Irrigation

Field 4 Extra Irrigated Cane		Field 4 Crop Cane		Field 15 Extra Irrigated Cane		Field 15A Crop Cane		Field 15B Monthly Irrigation	
Date..........	Irrigation Acre Inches....	Date..........	Irrigation Acre Inches....	Date..........	Irrigation Acre Inches....	Date..........	Irrigation Acre Inches....	Date..........	Irrigation Acre Inches....
Jan. 17/24	1.66			Dec. 1/23	2.06			Feb. 2/24	3.28
June 18/24	1.27			Jan. 26/24	4.29	Feb. 9/24	3.98		
June 25/24	1.36	June 25/24	6.09	Mar. 15/24	4.38				
July 3/24	3.55			June 7/24	6.51			June 23/24	5.44
July 12/24	2.50			June 17/24	5.29	June 23/24	8.83		
July 18/24	3.55	July 18/24	5.00	July 5/24	4.12			Aug. 18/24	3.79
				July 14/24	4.32				
July 25/24	2.58			July 19/24	3.50				
				July 26/24	5.58				
Aug. 4/24	2.42			Aug. 9/24	2.92			Oct. 11/24	2.11
Aug. 9/24	2.51			Aug. 18/24	3.54				
				Aug. 23/24	3.51	Aug. 23/24	5.71		
Aug. 16/24	2.65	Aug. 16/24	1.58	Aug. 30/24	3.40			Nov. 1/24	2.32
				Sept. 6/24	2.15				
Aug. 22/24	2.40			Sept. 13/24	2.04				
				Sept. 20/24	1.24				
Aug. 29/24	4.91			Sept. 27/24	2.33			Dec. 6/24	3.80
Sept. 5/24	3.46			Oct. 4/24	1.93				
Sept. 12/24	3.69	Sept. 12/24	6.80	Oct. 11/24	3.19				
Sept. 19/24	2.30			Oct. 18/24	1.24				
Sept. 26/24	2.87			Oct. 25/24	1.87				
Oct. 3/24	2.40			Nov. 1/24	2.28				
Oct. 10/24	3.14	Oct. 10/24	2.54	Nov. 8/24	1.00				
Oct. 17/24	2.52			Nov. 15/24	2.24				
Oct. 24/24	2.05			Nov. 22/24	.89				
Oct. 31/24	1.55			Nov. 29/24	1.22				
Nov. 7/24	2.03			Dec. 6/24	1.48				
Nov. 21/24	2.32								
Nov. 28/24	1.94								
Dec. 5/24	1.66								
	63.29		22.01		78.52		18.52		20.74

It will be seen that the extra irrigated cane in Field 4 received almost three times as much water as the crop cane. The extra irrigated cane in Field 15 received a larger proportionate amount, the total irrigation was four times the crop cane, and three and eight-tenths as much as the monthly irrigated cane.

CHART I
MOISTURE DETERMINATIONS
FIELD 4.

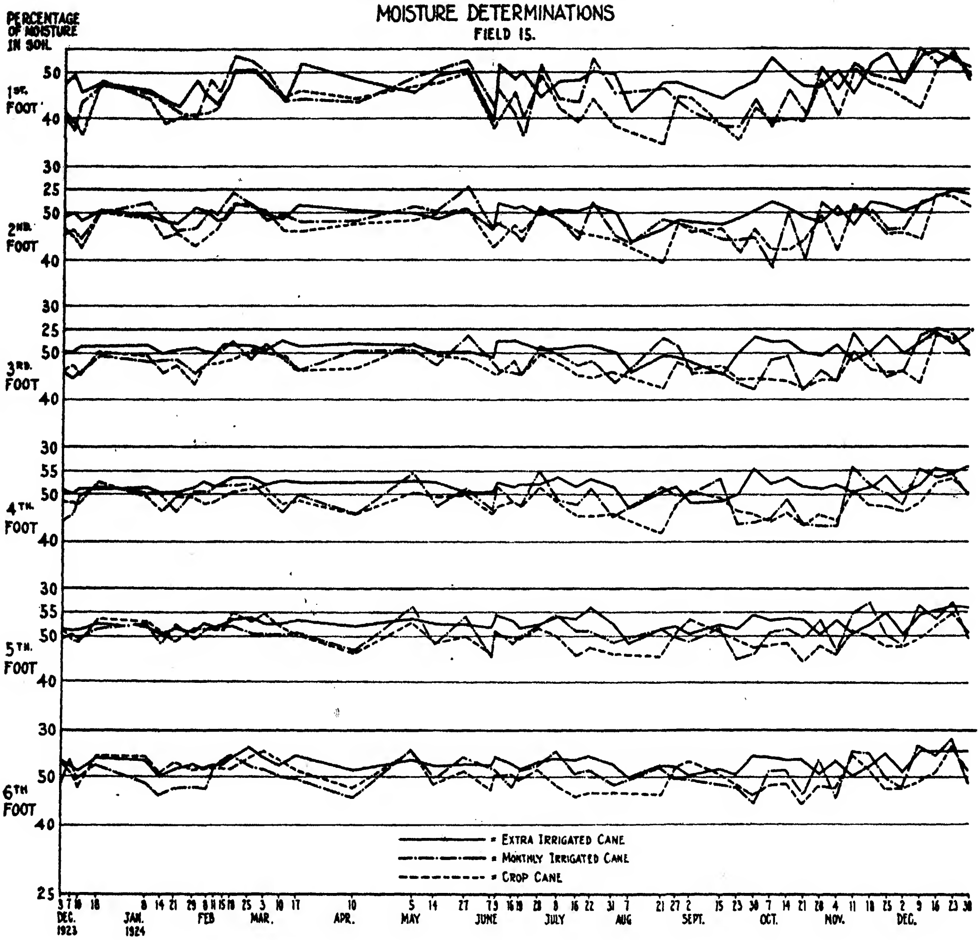


Determinations of Soil Moisture:

The moisture determinations made on the two fields are reported graphically in Charts I and II. Several interesting facts are shown by these graphs. In both fields the extra irrigated plots had a higher moisture content during the drier months of the year than the crop cane. There is, however, a striking difference in the moisture content maintained in the two soils by approximately the same amounts of water. The percentage of moisture in the less retentive soil occurring in Field 4 was notably lower both in extra irrigated and ordinary crop plots. In other words, it would probably take very much larger amounts of water to get as good moisture contents in the soil of Field 4 as in Field 15. This shows clearly the more effective use which is obtained from irrigation applied to a retentive soil than to a loose, open one.

The moisture contents in Field 4 rarely rose above 45 per cent in the extra irrigated soil until the cooler fall weather, and were still lower in the soil of the ordinary crop plots. This low range of moisture contents persisted, even down to the 5th and 6th foot in depth. In Field 15, the soil of the extra irrigated plots ranged from 45 to 50 per cent during most of the year, and was maintained at

CHART II
MOISTURE DETERMINATIONS
FIELD 15.



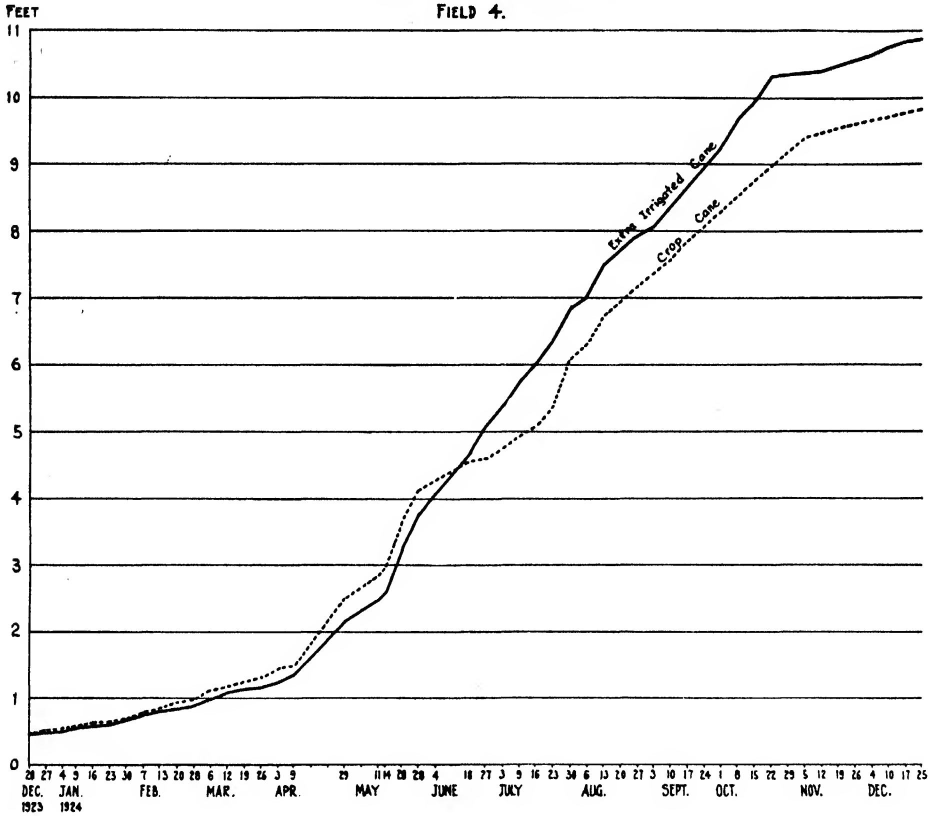
this level quite steadily after irrigation started in June. The differences in moisture content between the soils of the extra irrigated and ordinary crop plots are only noticeable in the upper four feet. Below this point the moisture content is more uniform, though even there the extra irrigated soil generally maintained a higher moisture content.

Measurements of Growth:

The measurements of growth are shown graphically in Charts III, IV, V and VI which give the growth, both as total elongation and by the weekly rate. No attempt will be made to compare the growth made in the two fields, as the cane is not only of a different variety but also of a different age. In each field the extra irrigated cane showed a notably better growth than the ordinary crop cane. These results are summarized in Table III. The final comparison of the actual efficiency of growth will be obtained from the harvesting figures later in the year. It is interesting to note that a noticeably better growth was obtained in Field 15, with fairly regular monthly irrigations, than was made by the crop cane, which received practically the same amount of water in acre inches. This reinforces

CHART II

COMPARISON OF TOTAL NEW GROWTH OBTAINED BY
EXTRA IRRIGATION AND ORDINARY PRACTICE
FIELD 4.



our conclusion drawn from the first season's work, that moderate regular irrigations were likely to give the most efficient use of a limited water supply.

TABLE III

Summary of Growth Measurements—Elongation of Sticks of Cane

Field No.	Treatment	Avge. Length Dec., 1923	Avge. Length Dec. 30, 1924	Increase Feet	Gain Due to Irrigation
15	Extra Irrigation	6.5	18.8	12.3	3.3
15	1 Month Irrigation......	3.2	13.0	9.8	.8
15	Crop Cane..............	2.8	11.8	9.0	..
4	Extra Irrigation	.4	10.9	10.5	1.1
4	Crop Cane..............	.4	9.8	9.4	..

Growth of New Shoots:

The weekly count of the total shoots present in typical watercourses was carried on in all the experimental irrigation plots. This is of interest as it shows the type of growth developed by different amounts of water. It also indicates whether the shoots survive until the crop is finally harvested.

CHART IV
COMPARISON OF TOTAL NEW GROWTH OBTAINED BY EXTRA IRRIGATION, MONTHLY IRRIGATION AND PLANTATION PRACTICE
FIELD 15.

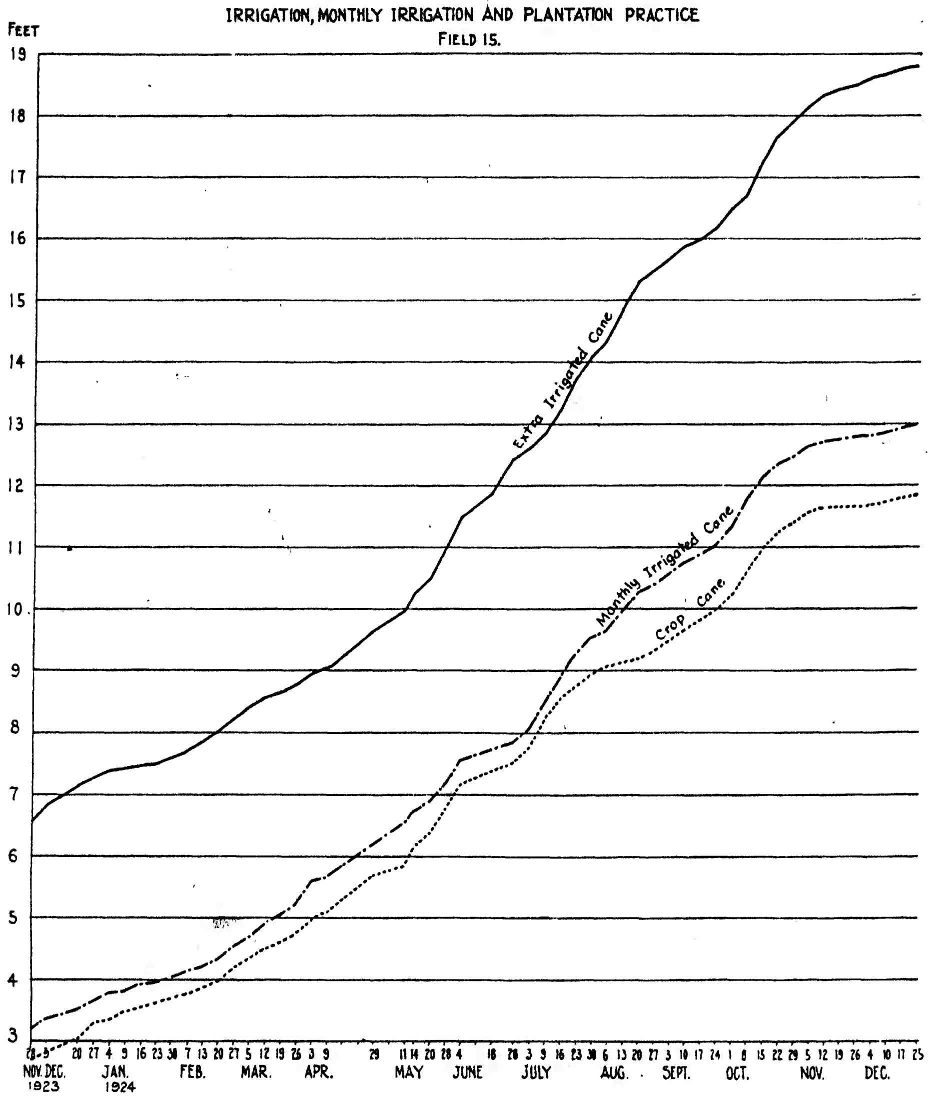


TABLE IV

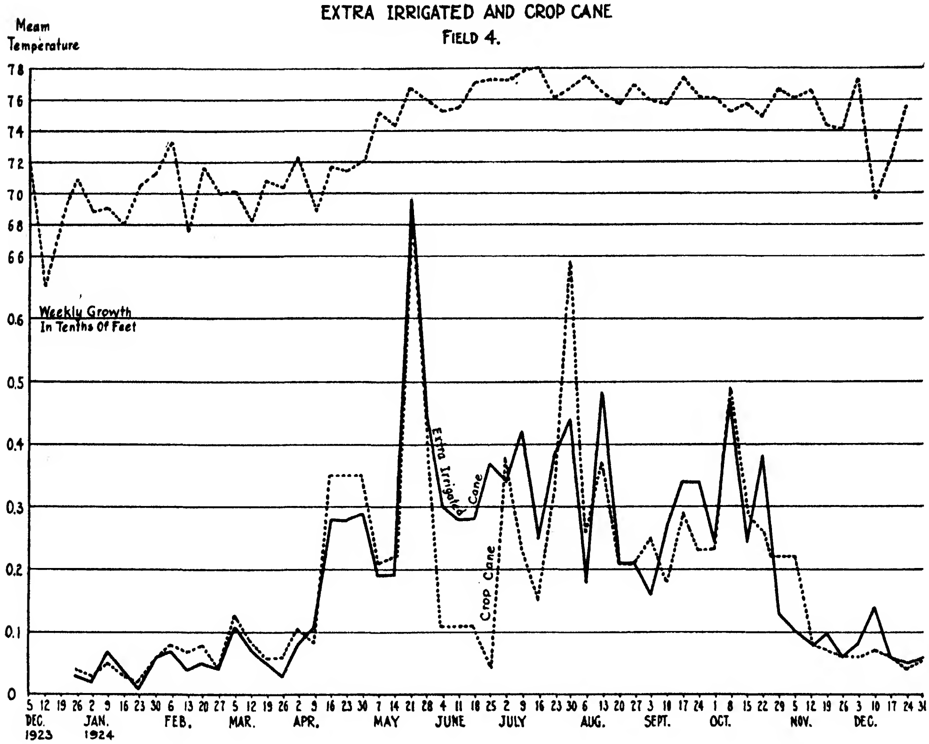
Development of Shoots in Irrigation Experiments

Field No.	Treatment	Number of shoots in watercourse December, 1923	Maximum Number present during season	Number of shoots surviving December 30, 1924
4	Extra Irrigated Cane...	77	206	154
4	Crop Cane.............	44	197	168
15	Extra Irrigated Cane...	83	102	71
15	Month Irrigated	98	120	88
15	Crop	101	120	84

CHART V

COMPARISON BETWEEN WEEKLY GROWTH OF EXTRA IRRIGATED AND CROP CANE

FIELD 4.



In Field 4, the watercourse chosen in the extra irrigated plot had a greater number of total small shoots than were present in the crop cane. With the more open growth prevailing in the crop cane, more new shoots were developed, but only a small part of these were of sufficient size to promise to become harvestable cane. The same relationship was found in Field 15. The crop cane and the 1 month irrigated cane had a greater number of small shoots and little sticks of cane than the extra irrigated cane. More adequate irrigation developed a smaller number of large sticks, of which a much greater number would be cane fit for the mill.

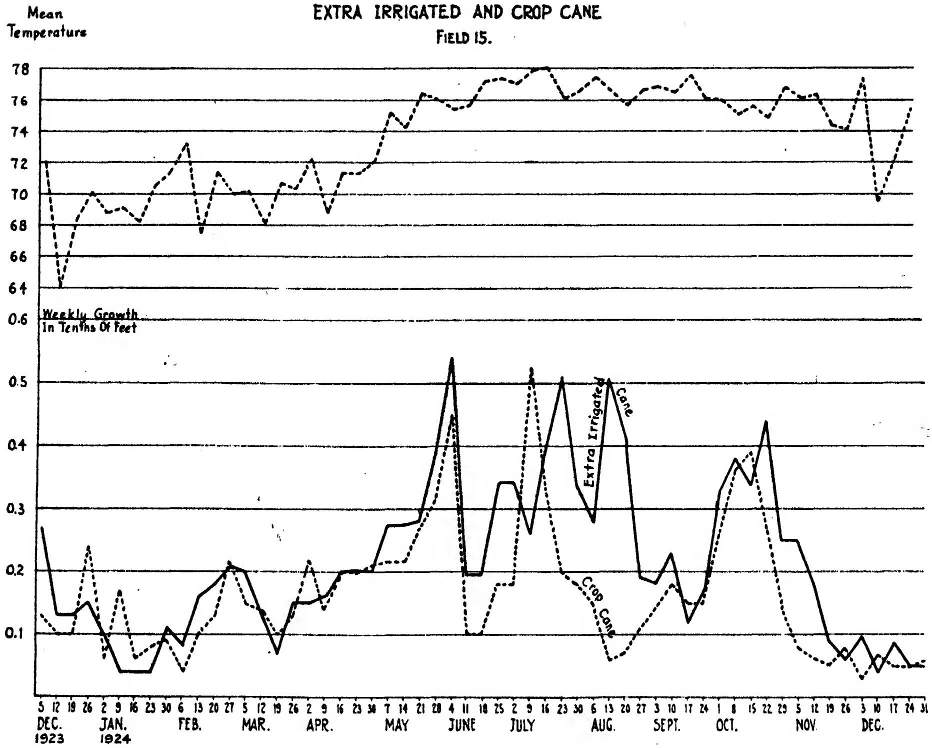
Effect of Temperature:

The effect of temperature upon cane growth is again clearly shown in Charts V and VI, where the mean temperature is plotted in comparison to the weekly rate of growth. In each of the two fields it is clearly seen that the decrease of the rate of growth in the fall is due to the drop in the mean temperature. The soil moisture had increased in the fall, due to lower transpiration and some rain, but this was not sufficient for rapid growth to continue when the temperature decreased.

CHART VI

COMPARISON BETWEEN WEEKLY GROWTH OF EXTRA IRRIGATED AND CROP CANE

FIELD 15.



Fertilization:

The cane in Field 4 has received a first season fertilization of about 765 lbs. of mixed fertilizer per acre. This supplied 85 lbs. nitrogen, 45 lbs. phosphoric acid and 45 lbs. potash. The second season fertilization consisted of 550 lbs. nitrate of soda, which furnished 85 pounds nitrogen per acre. As the cane was D 1135 and the stand only moderately thick, it was not considered advisable to apply additional nitrogen to the extra irrigated plot. The gain obtained from this experiment will only be due to the use of extra water.

Our report last year noted that we had applied 100 lbs. additional nitrogen to the extra irrigated cane in Field 15. This appeared to be justified by the heavy growth and the fact that the cane variety was H 109. The additional nitrogen was applied in early August, before the regular fertilization, which was applied in October, furnishing 110 lbs. nitrogen. The second season fertilization was 75 lbs. nitrogen from nitrate of soda, which was applied to all the plots. The extra irrigated cane therefore received 285 lbs. nitrogen per acre, and the crop cane 185 lbs. This additional nitrogen must be taken into account when the increased sugar yield is balanced against the value of the additional irrigation water which has been used to produce the larger crop.

Water Supply Studies

In order to find what amounts of water were available for irrigation throughout the entire season, a series of additional weirs was installed by Mr. Weinrich. These covered the Maunawili ditch, Kailua ditch and Pump ditch. Monthly reports have been made of these sources of supply by Mr. Weinrich and Mr. Beveridge, but the results of these measurements may be summarized here briefly.

Maunawili Ditch:

The supply from this source was remarkably constant during the past season. The daily average for the period of irrigation from June to November was as follows:

	Daily average
June	2,715,409 gallons
July	2,590,783 "
August	2,507,527 "
September	2,315,232 "
October	2,363,304 "
November	2,851,062 "

These figures show that this source of water was extremely constant and reliable. The greater portion of this water came from the Maunawili Ranch, but about 400,000 gallons daily were derived from various small sources on the Waimanalo side of the ridge.

Measurements were also made of the principal sources of supply upon the Maunawili Ranch which are not being used by the plantation. These outside supplies ranged in flow from a maximum of a million and a quarter gallons to a minimum of one million gallons during the two driest months. These two low months were September and October. The average daily flow during this time was as follows:

UNUSED WATER MAUNAWILI RANCH

	September gallons daily	October gallons daily
Maunawili Stream	141,100	208,100
Omao Stream	225,700	238,300
Ainoni Spring	325,000	298,300
Makawao Stream	355,000	325,100
	1,046,800	1,069,800

These figures show that these additional sources of water are as constant in flow as the Maunawili water which is now being delivered to the plantation. The problem of utilizing this water is an engineering question which is outside the scope of this study. Our work has shown that the flow is sufficiently steady at the driest period of the year to warrant consideration of the cost involved in bringing this water into the plantation ditch.

Lagoon Pump:

The measurement of the water obtained this year since the second pump has been installed has shown a very steady flow. The water delivered has varied from a minimum of 2,600,000 gallons per day, to a maximum of 2,870,000 gallons. This water is of course not equal to the mountain water in purity, but it is a valuable source of supply and has been made entirely safe for use by mixing with the Maunawili water.

Kailua Swamp:

The water obtained from the Kailua swamp has been more variable in amount than either of the other two sources. The figures obtained from measurement of the water delivered showed that the swamp furnished 4 million gallons of water per day in June. As the demand for water increased upon the plantation the amount pumped was increased to an average maximum of 6 million gallons per day in August. This heavy drain upon the swamp steadily lowered the level of the water, so that only 2,227,000 gallons could be pumped in October. The decrease in level is clearly shown by the staff readings which were taken beginning June 3, 1924. Upon that date the water stood 3.4 feet above sea level. At the end of the heaviest pumping period, October 7, 1924, the staff reading was 3.9 feet below sea level. This showed a decrease in level of 7.3 feet, which would indicate that at least part of the function of the swamp is to serve as a reservoir for the accumulated run off from the higher hills.

Seepage Losses

In order to determine the possibility of obtaining greater economy in the distribution of water to the fields considerable attention has been devoted to the determination of the losses of water by seepage from the ditches. In considering the question of seepage, the problem naturally divided itself into a study of the condition of the ditches which bring the water to the plantation, and secondly a determination of the losses in the actual plantation ditches.

Two main supply ditches bring the water developed outside the plantation on the Maunawili Ranch, and in the Kailua swamp, to the plantation fields. The figures for the seepage losses on the Maunawili ditch from its start, up to and including the tunnel, where the water comes upon the plantation, have averaged about 5 per cent of the total supply. The distance is not accurately measured, but is between two and three miles. The seepage loss is therefore seen to be extremely low for an earth ditch, or about 2 per cent or less per mile.

The figures for the seepage loss on the Kailua ditch, before it reaches the plantation, showed a slight gain in water. The ditch is partly lined and some water enters the stream in one of the tunnels, but it is probable that this apparent gain was due to the manner in which the weir crest was originally set in one of the boxes. This setting is now being changed so that comparable figures will later be obtained. It is, however, fairly safe to state that ~~the~~ loss upon the Kailua ditch before it enters the plantation is probably negligible. Attention to seepage losses may therefore be centered upon the main plantation ditches.

TABLE V

Seepage Losses

Pump Ditch

Location of weir	Distance between weirs	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
1—Field 22		1,285,000			
2—Field 11	3,320 ft.	1,020,000	265,000	20.64	32.82

Kailua Ditch

First Test

Location of weir	Distance between weirs	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Discharge pipe		4,442,800			
End of tunnels	11,648 ft.	4,664,600	none	....	....
Field 19	5,365 ft.	4,406,200	36,600	0.83	0.82
Field 15	3,276 ft.	3,996,600	446,200	10.04	14.84
Field 4	10,525 ft.	3,529,000	913,800	20.57	5.33
Field 3	4,915 ft.	3,015,900	1,410,900	31.76	12.02

Second Test

Location of weir	Distance between weirs	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Field 15		1,648,000			
Field 11	5,725 ft.	1,468,100	179,900	10.92	10.09
Field 4	4,700 ft.	1,399,700	68,400	15.05	4.64
Field 3	4,915 ft.	1,202,000	197,700	27.06	12.90

Maunawili Ditch

First Test

Location of weir	Distance between weirs	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Field 16		2,469,000			
Field 15	1,315 ft.	2,340,000	139,000	5.23	21.00
Field 14	7,275 ft.	2,113,000	356,000	14.42	6.67
Field 3	10,165 ft.	1,299,000	1,170,000	47.39	17.13
Field 1	5,623 ft.	1,125,000	1,344,000	54.43	6.38

Second Test

Location of weir	Distance between weirs	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Field 16		2,776,000			
Field 15	1,315 ft.	2,540,000	136,000	4.90	19.68
Field 14	7,275 ft.	2,372,000	404,000	14.55	7.00
Field 10	3,075 ft.	2,275,000	501,000	18.05	6.00
Field 4	4,200 ft.	1,661,000	1,115,000	40.17	27.82
Field 1	2,890 ft.	1,570,000	1,206,000	43.45	5.99

A study of the figures in the above table shows very clearly that there are appreciable losses in many parts of the plantation ditches. The highest loss per mile was found in the portion of the pump ditch which was measured. The seepage will be determined upon the remainder of this ditch as soon as the present crop is harvested. Several portions of the ditch are not accessible for the installation of weirs until the cane is cut.

Two portions of the Kailua ditch showed an appreciable loss, while two other sections only lost a moderate amount by seepage. This ditch appears to lose less water by seepage than the other two distributing systems. Even in this instance, however, the cumulative effect of the losses is quite appreciable. Almost

one-third of the water is lost when irrigation water reaches the end of the ditch in Field 3.

The Maunawili ditch showed a high loss in several portions. The cumulative effect of the seepage losses makes a very heavy water charge upon cane raised at the farther end of the plantation in Fields 1 and 3. Practically as much water is lost by seepage as finally reaches the cane.

In connection with the question of seepage losses, it is desired to allude again to the practice of growing cane along the main irrigating ditches and level ditches. This matter was touched upon in our report last year, where it was pointed out that cane growing in the ditches receives an unbalanced ration of too much water and too little nitrogen. The physical damage to the ditches is appreciable and the interference with normal stream flow and water distribution is very great. In addition to this, the penetration of the roots of cane or weed growth in the ditch banks greatly increases seepage loss.

There is a great deal of evidence as to the undesirable effect of growth in ditches. These observations have been made both under mainland conditions and in Hawaii. It is felt this matter deserves careful consideration in connection with the attempt to obtain greater economy in the use of water.

Distribution of Water to the Fields

The results obtained upon the determinations of soil moisture in Fields 4 and 15 exemplify the differences which may be found in two soils, where one is loose and open and the other is retentive of moisture. Similar soil variations are found in several portions of almost every plantation. It is therefore evident that if the attempt is made to keep the cane in each field in reasonably good condition to the eye this is likely to require the use of notably different amounts of water. In studying the problem of water economy it would therefore be desirable to know what amounts of water were applied to the different fields of the plantation. Should some soils prove to be notably loose and open in texture, requiring large amounts of water to produce satisfactory crops, or vice versa, producing poor crops with the same water which gave excellent yields elsewhere, it would be logical to concentrate to a greater extent upon the fields giving a better return per unit of water.

The desirability of such work was discussed with the manager, Mr. Chalmers, and it was found he was keenly interested in the value of the data which could be obtained. The plan has been developed of installing weir boxes, fitted for the Great Western Meters, in each of the fields when a new crop was started. In this way measurements were commenced upon a considerable part of the fields harvested in the last crop. It is planned to extend this work during the coming season and the attempt will be made to cover the entire plantation.

In this connection it would be desirable to follow the moisture content of a number of typical fields at intervals during the winter season. Very little winter irrigation has ordinarily been practiced at Waimanalo. Although the average winter temperatures are lower than those in summer, there is still sufficient mild weather at intervals to enable the cane to make a moderate growth

if the moisture is adequate. By following the moisture content of the fields it will also be possible to determine the time when it is necessary to start irrigation in the spring months.

Deductions to be Drawn from the Experimental Work:

The following conclusions appear to be justified by the work of the past two seasons: The results of the irrigation experiments point to the value of moderate, regular irrigations, which develop a continuous growth and enable the cane to utilize the rainfall to the best advantage. Extra irrigation applied to cane which was 10 to 12 months old, did not produce a satisfactory economic return. The effect of fairly full irrigation, from the time of planting, will be seen when the experiments in Field 15 are harvested this year. Up to the present our results show the greater value of regular monthly irrigation when contrasted with intermittent irrigation applied to the crop cane.

The value of these moderate, regular irrigations, and the difficulty of applying such small irrigations without excessive seepage loss, suggests the desirability of trying overhead irrigation upon an experimental scale. The harvesting results from this year's crop at Hawi Mill and Plantation Company, Ltd., are very encouraging. Better yields are being obtained by overhead irrigation than have ever been taken off their fields. It is believed the necessity for water economy at Waimanalo would warrant an experimental trial of possibly ten acres.

The differences in the moisture contents found in Fields 4 and 15 show the relative value of irrigation water applied to a loose, non-retentive soil, and to one which has a better water-holding capacity. The amounts of water applied to the two fields were not notably different, though the extra irrigated cane on the more retentive soil in Field 15 received slightly heavier irrigation. The moisture content was maintained at a more favorable level for crop growth in this better field. This demonstrates the advantage that may be obtained from using water on the best land.

The determinations of seepage losses have shown that attention may be confined, for the present, to the ditches inside the plantation. The seepage figures obtained on the Pump ditch and the Maunawili ditch showed a high rate of loss for portions of these ditches. The Kailua ditch showed an appreciable loss in two portions and a low loss in two others.

The high seepage loss on portions of the plantation ditches emphasizes the importance of keeping the ditches free from all growth. The roots of both cane and weeds increase the percolation of water out through the ditch banks. This unfertilized cane in irrigation ditches makes an extravagant use of water. At Waipio the fully irrigated, unfertilized plots have produced approximately 35 tons cane per acre. Similar adjoining plots receiving full fertilization have produced from 100 to 110 tons of cane per acre.

Recommendations for Further Work

1. Continuation of studies of seepage losses, after clearing the ditches of all growth.

2. Elimination of cane from all level ditches and distributing ditches.

3. The experimental trial of overhead irrigation.

4. Extend the measurement of irrigation water to all harvested fields, so as to determine the relative efficiency in sugar production obtained per unit of water applied.

5. Follow the moisture content of typical fields during the winter season, so as to determine if more winter irrigation would be advisable.

6. Install a series of growth, soil moisture and irrigation studies in typically different fields, as a further check on the efficiency of irrigation during the coming season.

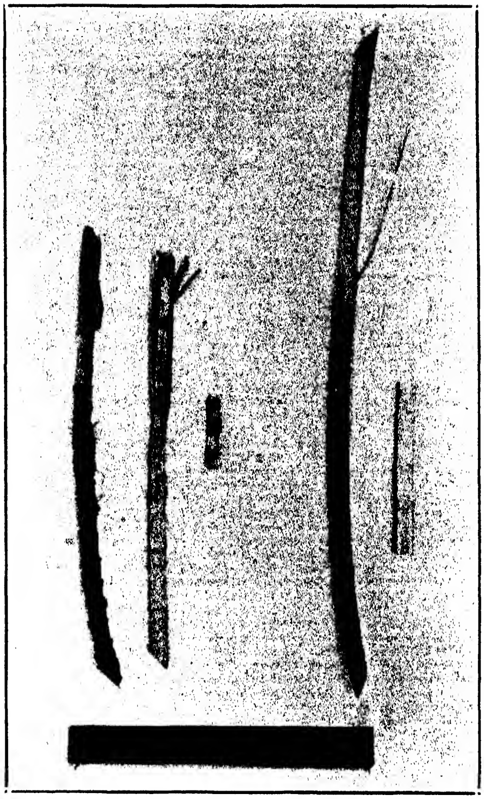
An Illustration of Aluminum Injury to Sugar Cane

By W. T. McGeorge

For some time the Chemistry department has been studying the effect of aluminum salts on the poor fertility or so-called root rot on the acid plantation soils. Extensive investigations throughout the United States and Europe have shown the salts of this element to be the principal toxic constituents of such types, and we have found these salts almost universally present in acid Island soils of certain acidity. In the accompanying illustration there is shown the most clear-cut example of aluminum injury to sugar cane yet observed during our investigation. Both cane stalks are D 1135 from Honokaa Sugar Company. That on the left is from Field 11, in which "root rot" injury is very serious. The reaction of the soil in which this stalk was grown is pH 5.5, which is within the range (5.8 or less) at which Hawaiian soils contain aluminum salts in the soil solution. Chemical tests on this stalk showed the presence of large quantities of aluminum and iron at the nodal joints. The effect of the aluminum is well shown in the numerous adventitious roots and in the disintegration and discoloration of the tissues at the nodal joints.

The stalk on the right, while equally stunted in growth, gave only an extremely faint test for iron and aluminum at the nodes, was free from adventitious roots and disintegration or discoloration of the tissues. The reaction of the soil in which this stalk was grown is pH 5.82 or slightly outside the range at which the aluminum salts are soluble. This field has responded notably to nitrate, indicating that the stunted growth is due to a nitrate deficiency and that it is not associated with any toxicity of aluminum, thus confirming the chemical tests and illustrating their value in identifying aluminum injury.

Aluminum injury is confined almost entirely to mauka fields. The acidity of Island plantation soils as a rule increases with altitude. A notable exception is the Kau district of Hawaii, where cane is grown at an altitude of 2,500-3,000 feet and where there are no acid soils even at this altitude. In view of the excellent crops grown at the higher altitudes in Kau and the absence of "sour" soils in



Comparing D 1135, stunted by aluminum (left, Field 11), and nitrate deficiency (right, Field 19). Note adventitious roots and discolored nodes in the former. These are entirely lacking in the stalk on the right.

this district, the question arises: Is environment (altitude) the primary factor in the poor growth of cane on the mauka lands of Kauai and the Hamakua Coast district on Hawaii? or is it not rather the higher acidity of the soils in the latter districts with the toxicity of the aluminum salts which are present at these reactions? It is at least of more than passing significance that the principal difference between the mauka areas of Kau and other Island districts is the difference in soil reaction.

The Relation of Root Injuries to Root Failure in Lahaina Cane

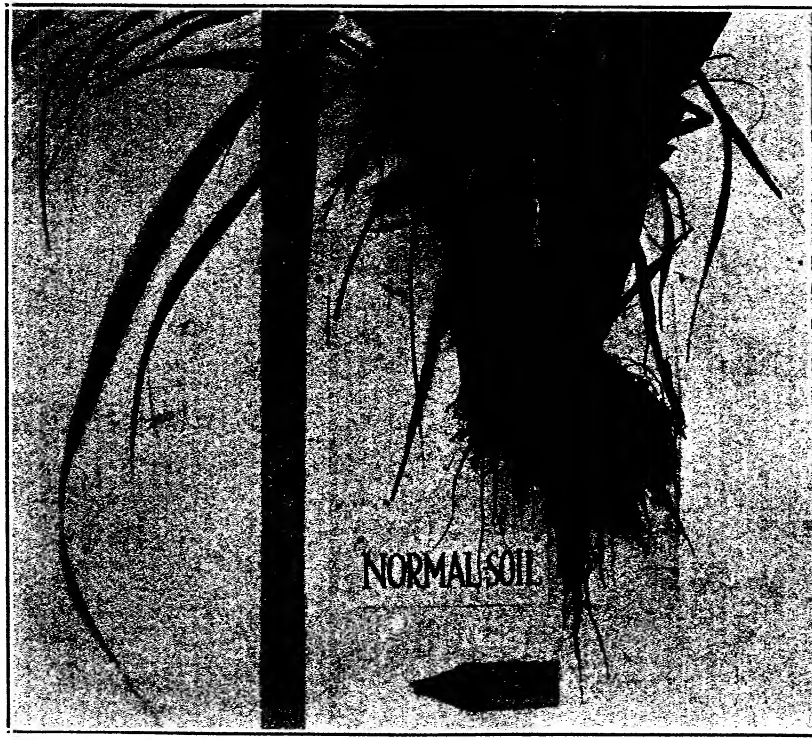
By Guy R. Stewart

The study of the chemical factors in the soil which are associated with the failure of the root system of the Lahaina variety of cane has been the major research endeavor of the Chemistry department of this Station for the past two years. Evidence has accumulated in the course of this work which tends to show that several unfavorable soil conditions have interfered with the growth of Lahaina cane in the Island sugar lands. Among these harmful influences we may mention the effect of high soil acidity and the accompanying toxic quantities of soluble aluminum found in some mauka lands. Notable deficiencies of potash and phosphates also appear to be predisposing causes of root failure. Shortages of these plant foods are often found in the highly acid soils. In other instances accumulations of salts from the irrigation water have caused injury from the soluble salts left in the soil, and in some cases have reacted with the soil minerals to produce an unduly alkaline soil reaction.

As these studies progressed it was frequently noted that a number of types of root injury often occurred in the cane fields. In some cases these root injuries consisted of definite cavities, possibly as large as a pin head; in other instances the holes were much smaller and were surrounded by reddish discolorations. Swezey (5) and others at this Station have reported that the larger cavities are often caused by minute snails. Pemberton (3) has shown that centipedes can cause similar damage to cane roots in the Honokaa district. Widespread root failure of sugar cane in Louisiana has been ascribed to snail injuries by Rands (4). The smaller minute root punctures with surrounding red areas, have been shown by Cobb (2) and Lyon to be caused by free living nematodes of the eelworm type.

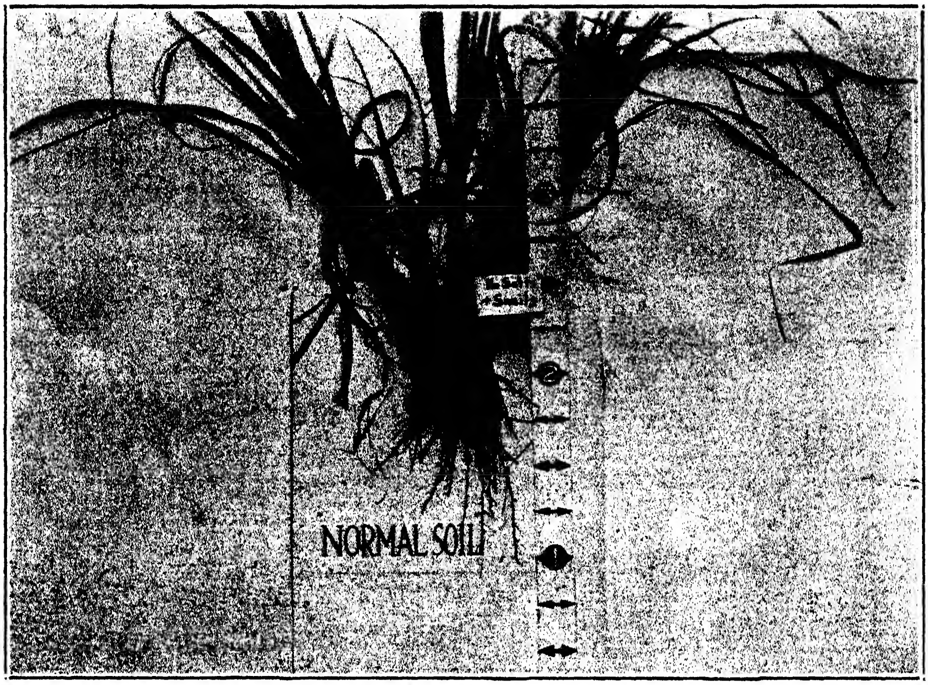
In view of the frequency with which these root injuries occur, it appeared desirable to have some more definite information as to the relative effect of root injuries contrasted with toxic soil conditions. The following preliminary experiment was therefore planned and carried out as a cooperative endeavor by the departments of Chemistry and Entomology.

We desired to try the effect of two unfavorable chemical factors in the soil. One of these was high acidity with toxic amounts of aluminum in solution. The soil chosen was from a highly acid area in the Kaneohe district where Lahaina cane failed in the days when this land was in sugar cane. This soil showed a reaction of 4.8 on the pH scale. In order to have controls with a favorable reaction, part of the tubs with this soil were treated with lime at the rate of 6



Growth of Lahaina cane in a good soil, partially sterilized, with a high concentration of soluble salts.

Growth of Lahaina in the same soil, without salts.



Root destruction of Lahaina cane in a normal soil, without salts, in the presence of snails and free living nematodes.

tons per acre foot of soil and superphosphate at the rate of 15 tons per acre foot added. Preliminary tests showed these treatments were sufficient to counteract the effect of the soil acidity.

The other unfavorable condition to be tried was a high concentration of soluble salts similar to that left by the evaporation of a slightly salty irrigation water. Owing to the difficulty of reclaiming a soil with a high salt content, it was decided to take a good soil in which Lahaina grows well and add salts to part of the tubs in sufficient amount to equal the salt found in bad spots in some poorly drained fields. The soil chosen was from Field 12, Oahu Sugar Company, where Lahaina cane still grows well.

We desired to try the effect of the root attacks of snails, free living nematodes and centipedes, both in the presence and absence of the unfavorable acidity and high salt concentration. The following treatments were made in duplicate to large concrete tubs, each of which held approximately 500 lbs. of soil. Each tub was 2 feet square and 2 feet deep:

PLAN OF EXPERIMENT

Acid Soil from Kaneohe

Acid Soil Untreated	Acid Soil Untreated
Acidity Neutralized	Acidity Neutralized
Acid Soil Untreated to Receive Snails	Acid Soil Untreated to Receive Snails
Acidity Neutralized to Receive Snails	Acidity Neutralized to Receive Snails
Acid Soil Untreated to Receive Centipedes	Acid Soil Untreated Centipedes Added
Acidity Neutralized to Receive Centipedes	Acidity Neutralized to Receive Centipedes
Acid Soil Untreated Nematodes Added	Acid Soil Untreated Nematodes Added
Acidity Neutralized Nematodes Added	Acidity Neutralized Nematodes Added

Normal Soil from Oahu Sugar Co.

Normal Soil Untreated	Normal Soil Untreated
Salts Added	Salts Added
Normal Soil to Receive Snails	Normal Soil Snails Added
Salts Added to Receive Snails	Salts Added to Receive Snails
Normal Soil to Receive Centipedes	Normal Soil Centipedes Added
Salts Added to Receive Centipedes	Salts Added and Centipedes Added
Normal Soil Nematodes Added	Normal Soil Nematodes Added
Salts Added and Nematodes Added	Salts Added Nematodes Added

This plan shows the arrangement of the duplicate tubs. It will be seen that half of the tubs of the acid soil were treated with lime and superphosphate, and half of the tubs of normal soil received salt treatments.

Before placing the soil in the tubs, it was subjected to partial sterilization by transferring it to small sacks holding about 10 lbs. These were then heated in a large autoclave at 15 lbs. pressure for one hour's time. We found by experiment that this period was sufficient to kill all soil inhabitants except the spores of fungi and bacteria. We desired to have the fungi and bacteria present in the soil in order to have them play whatever part they may in root deterioration.

Our original scheme, as indicated in the above plan, was to add snails, centipedes and nematodes to separate pairs of duplicate tubs in each series of treatments. We should thus have an opportunity in one series to observe the effect of these organisms upon the roots of Lahaina cane, both in a highly acid soil and in the same soil when the acidity was corrected. In the other series we should have the same organisms added to a thoroughly good soil, and to the same soil with a harmful amount of salt present.

There was greater root injury from nematodes in the normal soil, without salts, than where salts were added.

The tubs were all planted in November, 1924. We planned to add snails and centipedes to the respective pots as soon as the cane was well started. Mr. Swezey and Mr. Hansson spent many days searching for snails in the cane fields of Oahu. As a result of their efforts, we feel justified in stating that snails are not, ordinarily, sufficiently numerous in any large area of cane land on Oahu to exercise a harmful effect on the cane roots. Two minute snails, *Geostilbia Caecilioides baldwini* and *Subulina octona,* which are most concerned in root injury, have been noted in cane fields by various members of the Station staff. The only areas in which the molluscs have appeared to be numerous, have been poorly drained sections of land where the soil has been practically saturated with water. Under such conditions it is probable that they may increase for a time and become a factor in root injury.

Swezey and Hansson finally obtained a sufficient number of snails, 96, to add to one tub of cane. It was also difficult to find a sufficient number of small centipedes of the variety present in cane stools. Three tubs were eventually inoculated with centipedes.

The nematodes added to the tubs were of the minute eelworm type, which make a tiny red puncture where they enter the root. Cobb has identified this as *Tylenchus similis* (Cobb). These are not the variety which causes the large root galls commonly associated with nematode injury. The latter type is known as *Heterodera radicicola.*

The lime and superphosphate additions were made to half of the tubs of acid soil before the tubs were planted. Two top seed pieces of Lahaina cane were put in each tub and the most vigorous resulting plant was retained. After the cane was about 14 inches high, the additions of such centipedes and snails as were available were made. The nematodes were added in the form of small bundles of well washed roots, in which free living nematodes were found to be present. The soil surrounding the stools in the nematode tubs was carefully drawn away with a trowel and the infected roots were distributed around the large feeding roots of the young cane stool, and the soil replaced. At the time we made these inoculations, we had not been able to cultivate the free living nematodes on artificial media. Our inoculations probably consisted of more than one variety of nematodes, but the method followed was the best we had available at the time.

The salt treatments were made at about the same period that we added the snails and centipedes. Each tub received the following addition of salts listed in Table I:

TABLE I

Salts Applied to Oahu Soil

Salt	Amount
Sodium Bicarbonte ($NaHCO_3$)	100.9 grams
Potassium Chloride (KCl)	10.2 grams
Sodium Chloride (NaCl)	59.6 grams
Magnesium Sulphate ($MgSO4.7H_2O$)	49.5 grams
Magnesium Chloride ($MgCl_2.6H_2O$)	122.4 grams
Calcium Chloride ($CaCl_2.H_2O$)	221.0 grams
	564.6 grams

In order to prevent the loss of the soluble salts by leaching, no bottom drainage was permitted, and water was added in amounts that were just sufficient to keep the soils close to optimum moisture content. The same treatment in regard to drainage and irrigation was also given to the tubs of acid soil in order to make the conditions of growth comparable in the whole set of containers.

Injury from excessive moisture which might have accumulated in the tubs during heavy rainstorms was avoided by providing sets of removable covers, made of light boards and covered with heavy roofing felt.

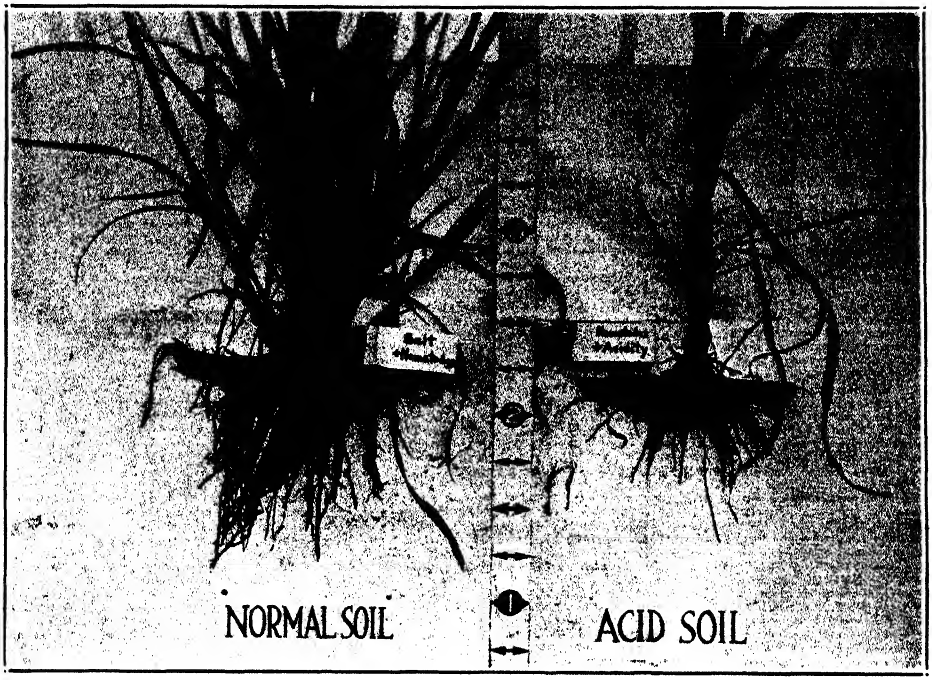
Three months after planting, the tubs were all fertilized with 45 grams of mixed fertilizer containing 11 per cent total nitrogen, 6 per cent phosphoric acid and 6 per cent potash as K_2O. This is equivalent to the application of mixed fertilizer at the rate of 1000 lbs. per acre.

At this same period it became evident that the application of the mixed salts to the Oahu soil was not causing the cane to be injured to the same extent that commonly occurs in the heavy textured lowland fields where salt accumulations usually take place. We at once made analyses to learn if the salts were possibly being washed down into the bottom of the tubs. The analytical results showed that the major portion of the salts was still in the top foot of soil. Several explanations suggested themselves. In most of the lands where salt accumulation

Full Acidity

Acidity Neutralized

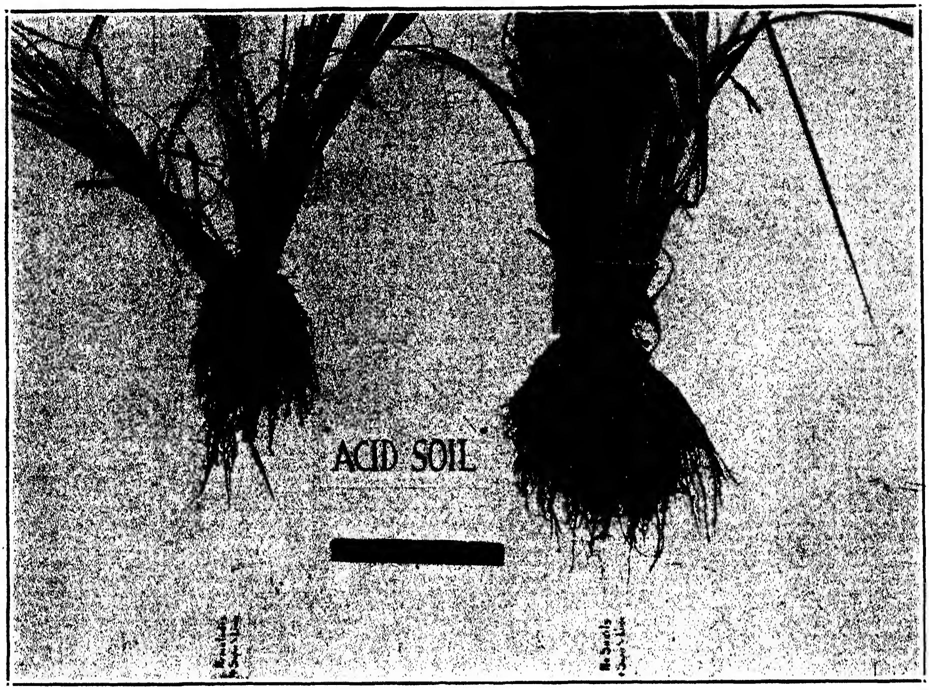
Growth of Lahaina cane in highly acid soil, after partial sterilization.



Root destruction caused by free living nematodes in a normal soil, with salts present, and in a highly acid soil.

takes place there is a notable injury to the physical condition of the soil, caused by puddling and deflocculation. The Oahu soil is an extremely open pervious silt loam, in which the salts caused no harm to the physical texture. It is also possible that much of the injury from salts may occur in field soils when the soil is rather dry and the concentration of salts in the soil solution becomes very high. We have analyzed soils from such areas where Lahaina failed in which the salts present in the soil solution amounted to 15,000 parts per million at the low concentration of 15 per cent soil moisture. The amount of salts added in our experiment would have developed an equally high concentration of salts, provided the soils had become rather dry, but this rarely, if ever, took place. In order to increase the effect of the salts, we made another addition, which was exactly one-half of the previous applications. This exerted some harmful influence, but not at all comparable to the effect which such large additions of salts have in the field. Such a result makes it appear possible that the partial sterilization had caused a sufficient biological or chemical change in the soil so that the toxic effect of the salts was reduced. This seems more probable since we had somewhat the same experience with the unfavorable acid soil. After the partial sterilization there was a notably better growth than was previously obtained in this soil.

The cane in the tubs was allowed to grow until about June 1 of this year, when it was dug up and careful observations, combined with microscopic examinations, were made of the root systems. D. M. Weller assisted us in sectioning



Comparative root and top development of Lahaina cane in a neutralized acid soil, in the presence and absence of free living nematodes.

and examining the cane roots, and J. P. Martin by working on the separation and cultivation of free living nematodes.

We found the most serious root injury had occurred where the free living nematodes were present. The stools infested with these nematodes were seriously stunted and the roots had largely disappeard in all the soil treatments. The development of roots and tops, where nematodes were present, is shown in the accompanying cuts. These are compared with cane stools growing in the normal soil with and without salt and in the acid soil, both neutralized and untreated.

The free living nematodes added to our soil cultures are a common soil inhabitant and are probably kept under control, to a certain extent, by other predatory soil nemas. Cobb (1) described three species of the genus *Mononchus*, the species of which have been demonstrated to be predaceous. In some of our cultures of nematodes, we have watched some of these attack and destroy *Tylenchus*. The presence of species of *Mononchus* may account for some of the contradictory results of experiments and field observations.

The roots of the one stool which had been inoculated with snails were badly injured but we found very few snails present. It was discovered that nematodes had been introduced into this tub, which may possibly have occurred in some traces of soil adhering to the snails. At present it ~~is~~ impossible to say whether the root destruction shown in the accompanying cut was due to snails or the nematodes accidentally present.

The centipedes which had been added to three tubs of cane had almost entirely disappeared. Very few remained in any of the three cultures and the roots of the stools where they had been present were almost entirely free from injuries. We are inclined to believe that the conditions were not entirely favorable for the growth of centipedes in our tubs. The ordinary cane field has more decaying organic matter present on the ground and in the soil than was found in our containers. Certain districts may be exceptionally favorable to the growth of centipedes and their free movement in the soil. This seems evident from the valuable observations of Pemberton at Honokaa. It is therefore possible that centipedes may be more injurious at times than would appear to be the case from our results.

Upon examining the uninoculated control stools we found that the roots of several of these stools were beginning to fail and decay in the soil. There were no root injuries on these stools, so it would appear that soil fungi and bacteria must also be reckoned with as an associated cause of root failure. It may be possible that the continuously moist condition of our soils was a favorable condition for these organisms.

In general we may note that toxic soil acidity and harmful concentrations of salt were not so fatal to the cane in this experiment as in ordinary field culture. This preliminary experiment clearly indicates that we must widen the scope of our investigations into the causes of root failure. Free living nematodes were associated with serious root injury. Their activities may be partly controlled, under field conditions, by other predatory nematodes. We also found that the roots of large healthy stools were beginning to fail where no injuries were present. It will require further controlled experiments before we can say definitely what relationship the various soil nematodes, fungi and bacteria, all have to root failure of sugar cane.

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Further Studies on the Saline Accumulation in Irrigated Fields

By W. T. McGeorge

This article is a continuation of our studies on the saline accumulation in irrigated fields. There is presented an experiment showing the improvement obtained in the growth of Lahaina by leaching away part of the saline material and the comparative growth of Lahaina and H 109 in water cultures containing the basic sulphates present in such soils and the basic chlorides singly and in combination. The literature covering previous work in Hawaii on this problem is reviewed, as well as certain pertinent discussions at annual meetings of the H. S. P. A., and these have been brought up to date.

In our studies on the infertility of Hawaiian soils cropped to sugar cane the complex nature of the problem was early indicated. As in many such investigations, we are rarely confronted with a single active agent, but usually find several factors of more or less importance associated. For example, in the investigation of the toxicity of our acid soils, there is convincing evidence that salts of aluminum are the principal toxic constituents of these types. No attempt was made to attribute the infertility of these acid types entirely to these salts, but rather to point out the importance which should be attached to their presence. There were found notable plant food deficiencies associated with these acid conditions. Again, it is impossible to estimate the extent of the aluminum injury, as it has been shown that in subtoxic concentrations there is a predisposition of the plant tissues to fungus invasion. At what stage the fungus enters or, in other words, the limit of chemical toxicity is difficult to establish and after identity sometimes equally difficult to correct. The actual chemical destruction of plant tissues in the field is rarely noted, as fungi and bacteria become active quite rapidly following impaired growth from chemical toxins. In other words, root injury must needs be accompanied by bacterial or fungal processes. On this basis it hardly seemed tenable to attribute to aluminum salts more than a primary predisposing role in sugar cane root or stalk rot, which condition the cane often acquires in our fields of low fertility. This same line of reasoning applies where infertility is the result of other soil conditions and any such investigation must be considered incomplete without a knowledge of the role of these organisms. In fact it is the present trend in soil chemical investigations to look upon chemical toxins as predisposing agents only. Although at certain concentrations plant growth may be entirely checked, such condition is rarely met in practice, the subtoxic concentrations being most often prevalent.

Data obtained in our study of the toxicity of aluminum salts showed that they were present only in acid soils of a certain degree of acidity which is usually found only in mauka and unirrigated fields. Many of the lowland irrigated fields may be classed as of low fertility if the failure of Lahaina in these districts may be taken as a criterion. A preliminary study of these areas along with a review of the work (10) of former members of the Experiment Station staff, as well as the observations of a number of the managers of irrigated plantations, strongly indicated that the accumulation of saline material from the irrigation water was an important growth retarding factor in these areas. In other words, that the Lahaina failure or deterioration of fertility in many of the irrigated fields is in the main a pathological or physiological condition of the cane induced in large part by the gradual accumulation of an excess of soluble salts from the irrigation water beyond the tolerance of certain varieties.

It appears from the above that we are confronted with what might be termed the "common experience" in most irrigated agricultural districts, arid or semi-arid, where surface evaporation or moisture requirement exceeds rainfall. A rise in water table usually follows extensive irrigation in lowlands. Soil water may be drawn to the surface through capillary action, there to deposit its saline content by evaporation, which material at certain concentrations is toxic toward many agricultural crops. Danger from rise in water table locally would apply mainly to the low lying fields near sea level. On the other hand, other factors may contribute to saline accumulation even in the absence of a marked rise in water table. Immediately following the draining away of the gravity water resulting from an irrigation or rain, capillary action begins to pump the water back to the surface of the soil. From this it is plainly evident that in a dry year or in the absence of occasional excessive irrigations the saline content of the soil solution within the zone of root growth will be greatly increased.

There is probably no other phase of soil infertility which has been more extensively or intensively studied than the alkali problem. The literature covering these investigations is legion and in the main shows the toxicity of the saline accumulations to be proportional to the concentration in the zone of root activity. The nature and ratio of the saline combinations are also governing factors. Unfortunately, it is not possible to foretell with any degree of certainty the sub-toxic concentration of alkali in soils. This is in large measure due to soil variability and a lack of knowledge of the physiological effects of the so-called alkali salts and the widely variable ratios which are possible in the soil solution, that is, the salt-plant ratio as well as the soil-salt-plant relationship. We know that a high concentration of saline material entirely restricts plant growth and that small amounts are essential. In the intermediate concentrations, from which arise the varying degrees of toxicity, numerous physiological disturbances are possible and it is these with which we are concerned. The difficulty in definitely identifying the principal growth retarding factor is apparent. The per cent alkali in soils tells us little about how plants will be affected. It is the strength and nature of the soil solution in which the roots are bathed which concerns most. The physical or mechanical condition of the soil induced by or accompanying the saline accumulation is also a factor in the fertility of these types which makes

more difficult any estimation of their fertility. Island soils in which excessive accumulations have taken place can usually be immediately identified by their highly adhesive properties or "sticky" texture.

The writer believes that one of the big problems in the study of soil fertility on Island irrigated plantations involves the accumulative tendency of saline material from artesian irrigation water and its effect upon the soil and growth of cane. There has unquestionably been, in the past, a notable accumulation in some fields. Is it not better, therefore, that our investigations precede rather than await such time as the fertility of these fields is greatly impaired, assuming that such may in time occur?

Plan of Investigation

As a means of investigating the role which saline accumulation played in the failure of Lahaina, the following line of study was taken up:

1. To remove the actual soil solution by displacement from a representative number of irrigated soils and to determine by analysis the composition of these.
2. To determine the effect on plant growth of reducing the soluble saline content by leaching these soils.
3. To study by water and sand cultures the toxicity of the salts found in the above analyses toward sugar cane, comparing Lahaina and H 109 varieties.

Review of Literature

Often in alkali soils some one class of salts will predominate. Thus we have sulphate alkali, carbonate or "black" alkali and chloride alkali. Sulphate alkali is generally considered the least harmful toward plant growth. In most of the soils thus far examined by the writer, chloride salts are in excess and it is in the physiological effects of this class on sugar cane that we are most interested here. There has been considerable work done on the action of chloride salts upon plant growth and, as above stated, there has been found a lesser tolerance than for sulphates. In fact a number of investigators go so far as to condemn the use of chloride (muriate) of potash on this basis. Experimental evidence is not lacking, confirming this contention as applied to some crops, which of course is not true for all.

Loew (7) found that calcium and magnesium chlorides have an injurious effect on plants probably on account of the liberation of hydrochloric acid in the cells, this not being assimilated like sulphuric and nitric acids and therefore accumulating to a noxious degree.

Wheeler and Hartwell (18) found calcium and ammonium chlorides to exert a marked poisonous action on certain plants.

Tottingham (17) says: "It is certain that some seed plants contain much more chlorine than others; that some may endure much higher chloride concentration about their roots than others and that differences in the amount of this element in the soil are frequently accompanied by characteristic differences in development and growth. The species of plant, type of soil, and the complex of factors considered as climate, greatly influence the effects."

In Utah, where extensive accumulations of sulphates and chlorides have been found in soils, Harris (5) found that "the anion or acid radical and not the cation or basic radical determines the toxicity of the alkali salt. Of the acids used the chlorides were decidedly the most toxic, while sodium was the most toxic base." He gives the chlorides in the following order of toxicity: sodium chloride, calcium chloride, potassium chloride and magnesium chloride.

Harter (6) has shown that plants grown in saline solutions undergo modifications of structure which reduce transpiration. Increase in thickness of cuticle and a deposit of wax upon the leaves results from excess of soluble salts. The absorbing capacity of the roots is checked, creating a physiological drought. In other words, the physiological changes in the plant are due to attempts to reduce the rate of transpiration. It is of interest to mention at this point that this same condition was often noted in the so-called Lahaina disease on the irrigated plantations.

Loew (8) has noted in the presence of injurious concentrations of sodium chloride a retardation of the assimilation processes in leaves, a reduction in chlorophyl and a decrease in sucrose content of sugar beets.

In India, Row (16) has given some attention to the growth of sugar cane on saline land. He found sodium chloride to be the principal growth retarding salt and showed that an excess of this salt increased the chlorine content of the juice and lowered the juice purity, sucrose and glucose content. He says that thick juicy cane varieties will not come up at all in saline land, while the thin, less juicy varieties are less affected by the salt.

Reed and Haas (15) working on orange trees found that large amounts of chlorides cause tip burn and abscission of leaves and death of young shoots. Sodium chloride restricted root growth and death of old leaves in concentrations greater than 1,000 parts per million. Calcium chloride increased growth of roots and tops up to 3,000 parts per million, although slight injury was caused by the highest concentration. Orange trees growing in saline soils were greatly benefited by leaching.

No attempt is made at completeness in the preceding review of the literature, but rather it is the intention to stress the generally recognized property of chlorides in retarding plant growth. A large amount of work has been done on the toxicity of chlorides as single salts, under which conditions it is an easy matter to determine the toxic range. The problem becomes complex when one attempts to reproduce soil conditions, as here we encounter an almost indeterminable array of several salts present in widely variable ratios. As the question of saline accumulation and its relation to plant growth is by no means a new subject in the Islands, it is of interest to review in some detail the previous work of members of the Experiment Station staff on account of its direct bearing on our present observations.

Early attention was given to saline soils by Maxwell (9). He noted some localities sufficiently contaminated by sea water as to be destructive to vegetable life. In most instances he says the deleterious agent is common salt; in others there is a mixture of common salt with the chlorides of calcium and magnesium. He says the latter are the most injurious to plant life and in the lowlands lying

almost level with the sea where there are no means of getting these salts removed, their impregnation renders the soil useless. The following data published by him show some effect of the salt on sugar cane:

SALT IN HAWAIIAN SUGAR LANDS AND ITS EFFECT UPON SUGAR CANE

Soil No.	Location	Per Cent Salt in Soil	Condition of Cane
1	Highlands	.061	Normal
2	"	.063	"
3	"	.050	"
4	"	.059	"
5	Lowlands	.129	Not wholly healthy
6	"	.130	Not wholly healthy
7	"	.155	Quite healthy and normal
8	"	.181	Yellow color
9	"	.181	Yellow color
10	"	.460	Small, yellow, stunted
11	"	.832	Cane white and dying
12	Sea bluff land................	.223	Leaves bleached, cane small

From the above he concluded that soils containing over .15 per cent salt, unless a liberal allowance is made of some element to force on the growth, the sugar cane is liable to suffer.

Further data which he presents are of interest and include the yield of three parts of one field which contained different amounts of salt in the soil. The soil in other respects was identical:

EFFECT OF SALT ON GROWTH OF CANE

Field	Salt in Soil Per Cent	Yield of Sugar per Acre in Tons
First part	.10	6.0
Second part	.45	1.5
Third part	1.00	0.0

In order to show the sensitiveness of sugar cane to salt and the ease with which the plant takes it up, he presents the following:

EFFECT OF SALT ON SUGAR CANE

Condition of Water	Salt in Water Per Cent	Salt in Cane Juice Per Cent	Condition of Cane
Slightly brackish	.125	.470	Growing
Highly brackish	.223	.714	Dying

He comments as follows: "In the above example the soils contained the same amounts of salt, about .15 per cent, which is too high to come in contact with even the slightly brackish water without detriment to plants. The extreme sensitiveness of sugar cane to salt content of water is made very clear. From our present experience the danger point should be placed at .14 per cent or 100 grains per Imperial gallon."

Additional work on this problem was done by Eckart (3) which, along with a number of calculations, is of interest. As an example he took a plantation using 2,500,000 gallons of water per acre per crop, which water was found to contain 125 grains salt per U. S. gallon. With such an irrigation goes 44,642 lbs. of salt during the growth of one crop. If the land in question was not irrigated to a point above saturation practically none of this water would drain off and the salt would remain in the soil. On the plantation in question the salty water was having no apparent effect upon the cane. The manager did not feel that he was using an excess of water because if he decreased the amount applied the cane suffered. Eckart questioned whether it was a case of too little water or too much salt accumulation in the surface areas resulting from insufficient water to leach the salt to lower levels. He offered the suggestion that the cane in this case suffered from accumulated salt and not lack of water.

Eckart's work (2) on the effect of saline water on the soil and cane is also of interest. He showed experimentally that saline water passes through the soil quite rapidly, provided an outlet for subdrainage is at hand, and carries with it large amounts of lime, potash and magnesia. Thus he showed a tendency toward a preponderance of basic sodium through a replacement of the other bases or an establishment of a saline equilibrium. Heavy rains and excessive irrigations only can prevent the saline accumulation, but he emphasizes that with this must go large quantities of calcium, magnesium and potash. He determined the relative toxicity of these salts by tub experiments. In these he showed the toxicity quite conclusively, depending, however, on the rate and quantity of irrigation water applied as well as the nature of the soil. From this work he concluded that when occasional excessive irrigations are applied to cane growing in tubs (constructed so as to allow free drainage), the use of irrigation water of high salt content only checked in a small measure the growth of the cane. Without the excessive irrigations the cane died. He also showed that large quantities of lime were liberated and that the calcium chloride formed was less toxic than sodium chloride.

He next conducted these experiments on a field scale (4), which yielded even more convincing data. The tables showing the effect of saline irrigation upon the quality of the juice and yield of cane are of considerable interest and are reproduced below:

QUALITY OF JUICE

Salt per Gallon of Water	Brix of Juice	Sucrose of Juice	Glucose of Juice	Purity Juice	Gums Juice	Chlorine Grains per Gallon of Juice	Salt Grains per Gallon of Juice
None	20.28	18.90	.312	93.20	.43	9.8	16.17
200 grs.	16.46	14.40	.264	87.50	.53	93.1	153.63
200 grs.	16.56	14.50	.271	87.60	.56	84.9	140.17
200 grs.	15.89	13.80	.280	86.80	.50	105.2	173.67

YIELD OF CANE AND SUGAR PER ACRE

Salt Per Gallon of Water	Lime Added	Cane per Acre, Lbs.	Sucrose in Cane per Cent	Sugar per Acre, Lbs.
None	No lime	151,675	16.91	25,648
200 grs.	G. coral	42,311	12.88	5,449
200 grs.	Gypsum	42,108	12.97	5,461
200 grs.	No lime	30,085	12.35	3,715

He comments on the above as follows: "The difference in yield of cane and sugar was remarkable. As for the effect on the quality of the juices, the juice of the cane receiving saline irrigation was characterized by lower density, less sucrose and glucose, lower purity and a much larger concentration of salt than the juice from the cane receiving fresh water." Extra irrigation tended to materially increase the yield and quality of the cane.

Some experiments started by Blouin (1) in 1901 and continued to 1903 are also of interest. In these experiments amounts of salt in the irrigation water were varied from 50 to 200 grains per U. S. gallon. The data showing the yields of sugar and cane per acre and quality of juices are given in tabular form and are reproduced below:

IRRIGATION WITH SALT WATER

Salt per Gallon of Irrigation Water	Salt Added per Acre per Crop	Cane Yield per Acre in Lbs.
50 grains per gallon	14,159	135,675
100 grains per gallon	28,318	92,754
150 grains per gallon	42,477	102,744
200 grains per gallon	56,636	79,860

ANALYSES OF JUICES

Salt per Gallon Irrigation Water	Brix	Sucrose per Cent	Glucose per Cent	Purity	Chlorine per Cent	Chlorine Grains per Gallon Juice
50 grains	19.79	18.1	.249	91.46	.0520	30.212
100 grains	20.07	18.3	.219	91.18	.0758	44.04
150 grains	18.89	17.0	.281	89.99	.0778	45.086
200 grains	18.07	16.35	.534	90.42	.1010	58.681

YIELDS PER ACRE

Salt per Gallon Irrigation Water	Cane per Acre	Sucrose in Cane per Cent	Suger per Acre
50 grains	135,675	16.2	21,979
100 grains	92,754	16.38	15,193
150 grains	102,744	15.22	16,638
200 grains	79,860	14.63	11,684

These tables show a close relation between the salt content of the irrigation water and yield of cane and sugar. Also, there was a steady decline in purity of juice with increase in salt, and along with this there was noted a drop in density and sucrose but a material increase in glucose.

Peck (13) has shown that the chlorine content of molasses is related to the source of the cane. It varied from .644 to 3.277 per cent, the lowest figure being obtained on molasses from unirrigated plantations. The more brackish the water, the higher the chlorine content of the molasses.

Composition of the Soil Solution

Taking the Lahaina failure as an indicator of infertility, a series of soil samples was collected from irrigated fields on the island of Oahu to study the composition of the soil solution. These samples were taken from areas where Lahaina was still growing or where it had previously failed. This phase of the investigation has already been published (10) and will not be repeated here. Suffice it to say that it showed unmistakable evidence of a large accumulation of saline material in many irrigated fields and a low vitality in Lahaina cane as compared to some other varieties notably H 109 and Yellow Caledonia when grown under such conditions. The chlorides were in all cases in excess of sulphates. Sodium, except in one case, was in excess of calcium, magnesium and potassium, while calcium was in greater concentration than magnesium. A rapid decrease in chlorides as a result of the winter rains was shown in this data.

These analyses have been recalculated to show the ratio of sodium, calcium and magnesium in the soil solution and also that of sulphates and chlorides. In these calculations magnesia was taken as 1 in the ratio of bases, while SO_3 was taken as unity in the SO_3 : Cl ratio.

TABLE 1

Ratio of Acid and Basic Radicals

Soil No.	MgO	Na_2O	CaO	SO_3	Cl
1	1	1.63	2.33	1	6.43
3	1	6.47	1.10	1	15.00
4	1	2.20	1.20	1	2.20
5	1	....	1.06	1	6.50
6	1	2.30	1.01	1	5.0
7	1	3.40	1.30	1	8.0
8	1	4.60	1.30	1	1.9
9	1	3.00	2.20	1	4.5
14	1	3.60	1.00	1	0.85
15	1	5.20	1.50	1	3.30
16	1	2.55	1.60	1	0.81
17	1	2.70	1.50	1	3.00

This table shows that it is not entirely a question of ratio of either basic or acid ions independent of concentration, but rather principally the latter. It is of interest to note the consistency of the magnesia-lime ratio in these soil solutions and the wide variation in the ratio of sodium to calcium and magnesium.

Leaching Experiments

Having shown in the study of the soil solution the higher concentration of saline material in the fields in which Lahaina grew with least vigor, our next

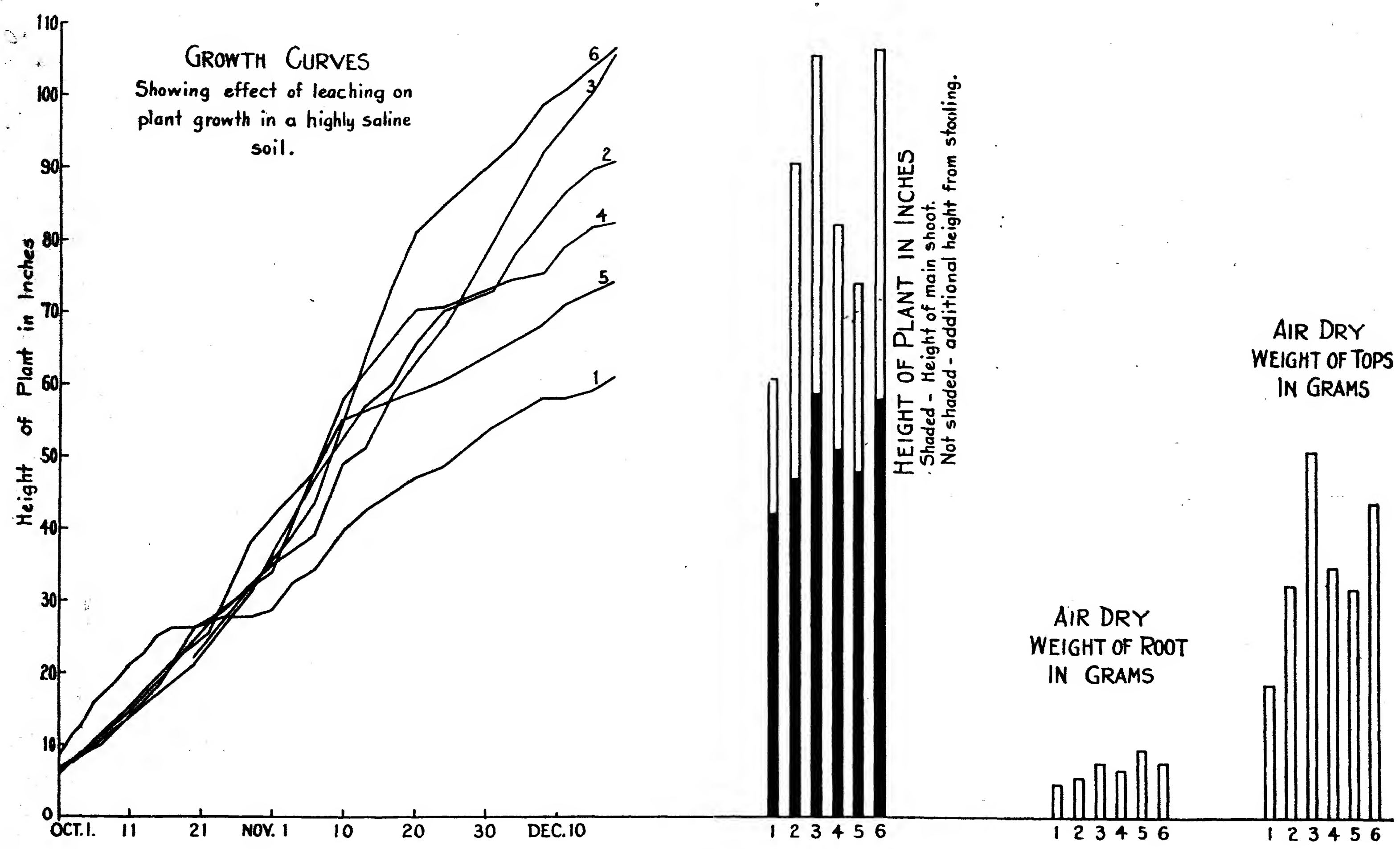
GROWTH CURVES
Showing effect of leaching on plant growth in a highly saline soil.
Height of Plant in Inches
110
100
90
80
70
60
50
40
30
20
10
0
OCT. 1.
11
21
NOV. 1
10
20
30
DEC. 10
1
2
3
4
5
6
HEIGHT OF PLANT IN INCHES
Shaded - Height of main shoot.
Not shaded - additional height from stooling.
AIR DRY WEIGHT OF ROOT IN GRAMS
AIR DRY WEIGHT OF TOPS IN GRAMS

Fig. 1

step was to show the effect of leaching such a soil upon the growth of Lahaina. With the exception of black alkali (sodium carbonate) the other alkali salts may be leached from soils with comparative ease by excessive irrigation. With this in mind a quantity of soil was obtained from such a field, placed in tubs (40 lbs. soil per tub) and the following series of treatments were carried out:

1. Unleached soil was placed in the tub just as obtained from the field.
2. Four gallons of water were added, equivalent to 2,000,000 gallons per acre per crop or one crop's irrigation.
3. Same treatment as 2 except 8 gallons of water, equivalent to 2 crops, were used.
4. Twelve gallons equivalent to 3 crops.
5. Sixteen gallons equivalent to 4 crops.
6. Twenty gallons equivalent to 5 crops.

The water was applied at the rate of 2 gallons per day, allowed to stand over night and then drained off by subdrainage. This was continued daily until each treatment had received its full application of water. The leachings were collected, measured and aliquots taken for analysis in order to determine the amount and composition of the saline material removed.

Effect of Leaching on Growth: Each pot was planted with one Lahaina seed (three-eye seed with two eyes pinched out) on September 18, 1924. Growth measurements were taken of the plants beginning October 1, and continuing to December 18. These results are shown graphically in Fig. 1. This figure shows the rate of growth, final height of main shoot plus additional growth from stooling, and final dry weight of roots and tops. These show very clearly the increased fertility obtained on removing the excess of saline material, and show that saline accumulation is a growth retarding factor in this soil.

Unfortunately, this soil is a very heavy clay, the particles of which have been greatly deflocculated by the saline material. The heavy leaching treatment given in this experiment greatly increased this puddled condition, thus checking the growth in the pots from which the salt had been leached. At the completion of the experiment the soil in the unleached pot was in a much better mechanical condition than the others, although poor itself. The soil particles in all pots were so closely cemented as to make it impossible to remove the roots intact for photographing.

The relation of climatic factors to toxicity of saline accumulation was also strikingly brought out in this experiment. On sunny days the leaves on the plant in the unleached pot were badly curled, as if suffering from drought, when as a matter of fact the soil was practically saturated. This characteristic curling was entirely absent in the pots receiving the heaviest leachings, and rarely noted in treatments 2 and 3.

From October 16 to November 1 there was very little additional growth in the check, after which renewed growth took place. This was due to a series of sunny days up to November 1, after which a month of cloudy and rainy days set in. Attention is called to the relation of such changes to the physiological effects of high saline concentrations. There is less toxicity where the rate of

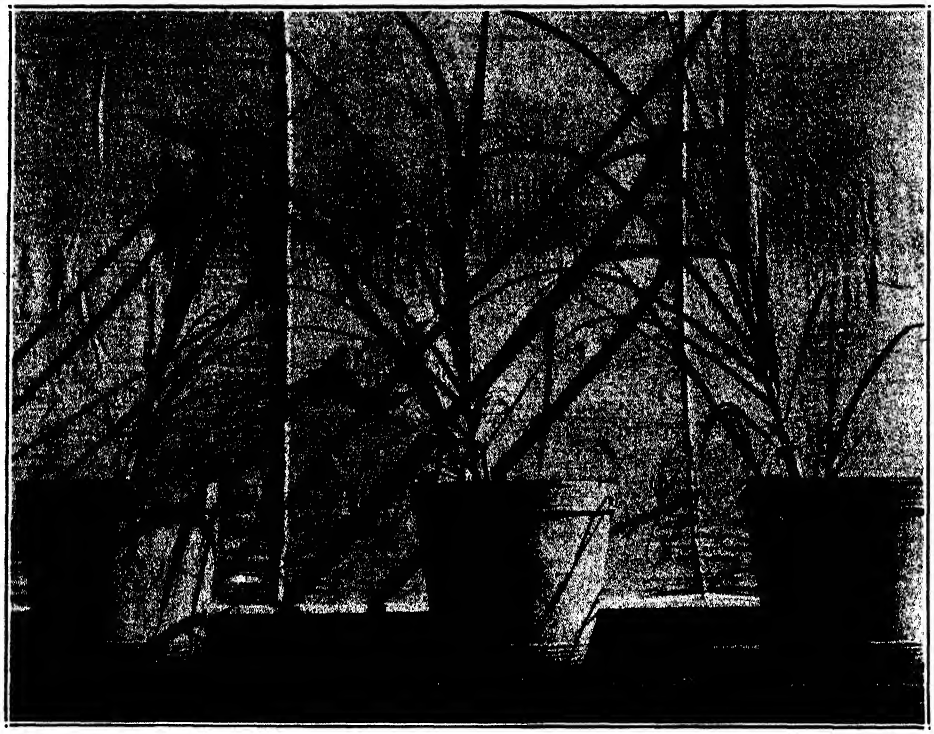

Fig. 2. Left to right: 1. Check—soil not leached. 2. Soil leached with one crop's irrigation. 3. Soil leached with one crop's irrigation.

transpiration is lowered by cloudy days, which is in agreement with the general observations on alkali lands. A high rate of transpiration such as takes place on dry, sunny days rapidly exhausts the plant vitality by a high rate of saline absorption in supplying the moisture passing through the plant and evaporating from the leaves. On December 18 the plants were transferred to the shelter of a greenhouse where, other than being stunted in growth, there was less outward appearance of toxicity than when grown in the open. The comparative growth of the plants is shown in Fig. 2.

It seems fair to interpret these observations as indicating that the growth of Lahaina cane will be greatly enhanced by the removal of accumulated saline material; and, further, that the concentration of salts in some irrigated fields has already reached sufficient accumulation as to seriously retard the growth of the Lahaina variety.

Mineral Composition of Plants: The roots and tops from these plants were analyzed separately in order to note the effects of saline material on the inorganic constituents of the plant. The results of the analyses are given in the following table as per cent of ash and as per cent of dry (water free) material:

TABLE 2

Composition of Tops in Per Cent Dry Matter

Pot No.	Ash	Silica SiO_2	Iron and Alumina $Fe_2O_3Al_2O_3$	Lime CaO	Magnesia MgO	Soda Na_2O	Potash K_2O	Chlorine Cl	Phosphoric Acid P_2O_5	Sulphur Trioxide SO_3
1	8.99	2.41	.37	.79	.85	.39	1.77	.70	.68	.55
2	8.40	2.23	.37	.55	.58	.41	1.83	.62	.63	.59
3	8.65	3.16	.36	.46	.53	.30	1.95	.65	.67	.55
4	7.72	2.97	...	.48	.52	.31	1.74	.51	.56	.49
5	8.53	3.36	.36	.44	.50	.64	1.42	.52	.63	.49
6	8.31	3.33	...	.42	.59	.24	1.89	.52	.58	.54

Composition of Roots in Per Cent Dry Matter

Pot No.	Ash	Silica SiO_2	Iron and Alumina $Fe_2O_3Al_2O_3$	Lime CaO	Magnesia MgO	Soda Na_2O	Potash K_2O	Chlorine Cl	Phosphoric Acid P_2O_5	Sulphur Trioxide SO_3
1	9.30	2.52	...	1.19	.54	1.03	.31	.40	.51	.66
2	7.66	2.47	2.22	.67	.42	.60	.55	.10	.64	.57
3	....	....	1.50	.70	.35	.48	.40	.04	.61	.41
4	7.75	2.27	2.44	.63	.43	.56	.73	.04	.55	.45
5	10.86	3.82	2.33	.61	.37	.52	.41	.02	.49	.47
6	7.32	2.72	2.17	.59	.35	.38	.49	.04	.55	.46

Composition of Ash in Per Cent Ash Tops

Pot No.	Ash	Silica SiO_2	Iron and Alumina $Fe_2O_3Al_2O_3$	Lime CaO	Magnesia MgO	Soda Na_2O	Potash K_2O	Chlorine Cl	Phosphoric Acid P_2O_5	Sulphur Trioxide SO_3
1	....	26.42	4.08	8.66	9.30	4.28	19.43	7.93	7.46	6.02
2	....	26.20	4.40	6.42	6.86	4.83	21.45	7.50	7.44	6.91
3	....	36.24	4.09	5.22	6.04	3.47	22.30	7.60	7.70	6.29
4	....	37.80	....	6.11	6.55	3.96	22.16	6.80	7.09	6.31
5	....	39.07	4.15	5.11	5.79	7.45	16.50	6.18	7.33	5.67
6	....	40.05	....	5.00	7.08	2.84	22.65	6.28	6.99	6.45

Composition of Ash in Per Cent Ash Roots

Pot No.	Ash	Silica SiO_2	Iron and Alumina $Fe_2O_3Al_2O_3$	Lime CaO	Magnesia MgO	Soda Na_2O	Potash K_2O	Chlorine Cl	Phosphoric Acid P_2O_5	Sulphur Trioxide SO_3
1	....	25.86	.....	12.23	5.58	10.55	3.24	4.52	5.28	6.83
2	....	31.22	28.10	8.58	5.32	7.69	6.92	1.40	8.08	7.18
3	....	.....	29.44	13.71	6.85	9.51	7.83	.66	11.96	8.04
4	....	28.16	30.22	7.79	5.32	6.94	9.12	.51	6.84	5.56
5	....	34.40	.....	5.53	3.31	4.70	3.69	.20	4.45	4.23
6	....	36.00	28.60	7.88	4.67	4.98	6.43	.54	7.29	6.07

Ash: With one exception, the ash or total mineral matter absorbed by the plant was less in the plants grown on the leached soils.

Silica: There is no difference in the amount of silica absorbed as per cent dry matter. On the other hand, on the basis of total mineral matter or ash present in the plants there is a greater ratio of silica in the ash of plants grown on leached soils.

Iron and Alumina: These elements show no consistent variation.

Lime and Magnesia: Lime and magnesia were taken up by the plant in decreasing amounts with increase in amount of water used in leaching, showing the high absorption of these elements probably as chlorides when a high concentration is present in the soil solution.

Sodium: The effect of sodium upon the mineral balance of the cane is shown principally in the roots. Here there is a very high absorption of sodium, which is materially reduced by leaching the soil. There is no consistent relation in the sodium content of the tops, indicating that calcium and magnesium chlorides may be the primary toxic agents in the above-ground parts of the plant. Other analyses which we have made have shown that it is characteristic of sugar cane to retain the largest amount of sodium in the roots, while potash is present in excess in the tops.

Potash: Here, again, the principal variation is in the roots, where increased absorption of calcium, magnesium and sodium has materially reduced the absorption of potassium in the unleached pot, while leaching the soil had the effect of increasing the absorption of potash. In other words, calcium, magnesium and sodium tend to retard potash absorption when present in excess. It is of interest to state that the field from which this soil was obtained responds markedly to potash fertilization.

Chlorine: The amount of chlorine absorbed by the plant is greatly reduced by leaching the soil, and, as shown in the illustrations, the growth of cane was very greatly benefited thereby.

Phosphate and Sulphate: There is no consistent relation in the phosphate absorbed. As for the sulphate content of the plants, the per cent dry matter shows a higher absorption by the roots in the unleached soil but no difference in the tops.

Mineral Matter Removed from the Soil by Leaching: The soil solution as removed from this soil by the displacement method was found to contain 14,408 parts per million solids with 5,388 parts per million chlorine. This is equivalent to practically 30 per cent of the total mineral matter and means that the plant roots would be bathed in practically an N/7 solution of salt at this moisture content. The per cent moisture in the soil used for the removal of the soil solution was 14 per cent and only slightly below what it would be under field conditions for this type.

The leachings from all pots were collected, well mixed and aliquots taken for analysis. The results are given in the following table:

TABLE 3

Composition of Drainage Water in Parts per Million

Pot No.	Total Solids	Silica SiO_2	Lime CaO	Mag. MgO	Soda Na_2O	Potash K_2O	Sulphur Trioxide SO_3	Chlorine Cl
1				not leached				
2	4178	23	531	279	506	43	588	1220
3	2692	23	338	180	463	30	360	768
4	1580	..	189	109	289	13	194	432
5	1358	20	172	95	279	15	186	372
6	1636	22	183	101	318	13	164	484

Amount of Each Element Removed per Pot by Leaching, Results in Grams

Pot No.	Total Solids	Silica SiO_2	Lime CaO	Mag. MgO	Soda Na_2O	Potash K_2O	Sulphur Trioxide SO_3	Chlorine Cl
2	39.7	.2	5.0	2.6	4.8	.4	5.6	11.6
3	60.6	.5	7.6	4.0	10.4	.7	8.1	17.3
4	58.5	..	7.0	3.9	10.7	.5	7.2	16.0
5	62.4	.9	7.9	4.4	12.8	.7	8.5	17.1
6	94.9	1.3	10.6	5.8	18.4	.7	9.5	28.1

After harvesting the plants in the pots the soils were analyzed for water soluble constituents by extracting one part soil with five parts water. It was the original plan to make analyses of the soil solutions obtained by displacement, but the soils were so badly puddled and in such a bad mechanical condition that it was impossible to pack it properly in cylinders. The results of these analyses are given in the following table:

TABLE 4

Composition of Water Extracts Calculated to Parts per Million Dry Soil

Pot No.	Total Solids	Lime CaO	Magnesia MgO	Soda Na_2O	Potash K_2O	Sulphur Trioxide SO_3	Chlorine Cl
1	3122	373	206	587	60	513	813
2	1264	127	63	311	38	184	177
3	1099	104	43	276	43	122	98
4	1101	110	64	226	45	103	103
5	1040	104	52	227	32	71	104
6	985	104	55	246	36	73	98

Table 3 shows the large amount of leachable material in this soil. It is composed in the main of the chlorides and sulphates of sodium, calcium and magnesium, with the former in excess.

The analyses of the water extracts of the soils at the end of the experiment show a remarkably constant composition in the soils which had received the equivalent of 2, 3, 4 and 5 years' irrigation. This agrees with the growth measurements obtained in the pot experiments, where it will be noted there was little or no increase in plant growth beyond the 2-year irrigation. This is undoubtedly due to the poor mechanical condition of this soil type and the treatments would probably have shown a higher extraction of saline material in a more porous soil.

Further discussion of the composition of the soil solutions and the data obtained in the leaching experiment is of interest at this point. It was found on studying the soil solution (10) that in ten cases out of eleven, sodium was in excess of calcium and magnesium, while in one case, that of the highest saline accumulation, calcium was in excess. In all cases except two (well drained soils) chlorides were in excess of sulphates. And further, in all cases calcium was in slight excess over magnesium.

The excess of calcium in the soil solution of highest concentration is of more than passing interest. It shows that calcium chloride is the most soluble salt present in these soils; that it will be most readily leached to the lower strata and is the slowest in returning to the soil surface during periods of evaporation. The downward movement of water through the pore spaces is much more rapid than the upward movement by capillarity, and therefore in the former will carry in excess the more soluble calcium chloride. The salts carried to the surface by capillarity and deposited as a crust by evaporation are in greater equilibrium, and will therefore carry less calcium chloride in proportion. Over an extended drought, however, or during the dry summer months if the soil surface is exposed, the soil moisture becomes saturated in the upper layer, resulting in the precipitation of the less soluble salts, notably calcium sulphate. There results from this a concentration of the chlorides of calcium and sodium, more especially the former. The correctness of this contention is further demonstrated in the composition of the leachings from the pot experiment, in that the first leachings show an excess of calcium chloride over sodium chloride, while in continued leachings this is changed to an excess of sodium chloride.

It is of interest to state that in some cases the growth of Lahaina on these soils has been improved somewhat by gypsum, which would tend to reduce the conditions above described. That is, a reaction between the calcium sulphate and sodium chloride would yield calcium chloride as one of the end products which would be more rapidly leached by the rains and irrigation water.

Further evidence of the presence of calcium chloride is shown by the "sticky" texture of the saline areas, this salt tending to retain for a longer period a saturated moisture condition. The highly hygroscopic properties of calcium chloride preclude its ever being deposited in the surface crust of salt, but rather to be present in a high degree of concentration in the soil solution.

Sand and Water Cultures Showing the Effect of Chlorides and Sulphates of Sodium, Calcium, Magnesium and Potassium on Lahaina and H 109 Varieties

In planning a series of water cultures it was necessary to run a preliminary experiment using concentrations covering a wide range in order to select a more restricted range for closer cultural study. This was necessary because of our lack of knowledge of the toxicity of these salts in pure culture. The highest concentration noted in our examination of the concentration of the soil solution from the field was approximately 6,000 parts per million chlorine or .2 to .1 normality. The culture solutions for the preliminary experiment were therefore made

up as .2, .1, .05, .02, .01 and .004 normality for the sodium chloride, magnesium chloride, potassium chloride, sodium sulphate and magnesium sulphate while the same were used for calcium chloride except that there was added a .4 normal solution, and the .004 normal solution was omitted.

As containers for growing the plants, one-half gallon glass percolators were used. These were filled with silica sand and an outlet allowed in the bottom of the percolator for the drawing off of the nutrient solution at varying periods (weekly), when fresh nutrient was added. Cane shoots were prepared by growing from seed pieces to a height of approximately ten inches, at which time they were cut from the seed piece and placed in the sand cultures with about one-half inch of the base below the surface. As a basic nutrient to which the salts were added, the following was used in this and the following experiments:

.2 normal calcium nitrate	15 cc. per litre
.1 " ammonium nitrate	10 " " "
.1 " potassium chloride	8 " " "
.2 " magnesium sulphate	8 " " "
8.3 grams per litre calcium phosphate	5 " " "
Ferric citrate	trace

The shoots were planted on December 19, two Lahaina and two H 109 in each percolator. Observations of the progress of the experiment were made from time to time, some of which are of interest.

December 30—Sodium Chloride Cultures: This salt appears to cause more distinctly rolled leaves, less bleaching, or chlorosis in high concentrations, but rather a brown, wilted condition, beginning at the tip of the leaves in Lahaina. With H 109, wilting is almost without loss of color in the higher concentrations, and where chlorosis does appear it occurs only along the tissues carrying the smaller vascular bundles, as in the yellow or bleached striping of Pahala blight.

Magnesium Chloride Cultures: The effect of the magnesium chloride is shown in a more solid, uniform bleaching of the leaves with no appearance of striping. This form of chlorosis is an exact reproduction of the chlorosis often noted in young shoots from stubble in many Oahu fields. In the highest concentrations the plants wilted without any development of chlorosis.

Calcium Chloride Cultures: In the stronger concentrations there is a notable wilting. At lower concentrations, .01 normal, the chlorosis takes the form of a stripe, such as described under sodium chloride.

In later observations, similar conditions as above described were noted. The experiment was continued to January 27, at which time the plants were removed and observations made on the roots as well where the plants were still alive. Detailed observations are omitted because these will be taken up in the experiments to follow. In general, speaking of the plant as a whole, there was indication of a greater resistance to chlorides in the H 109 as compared to Lahaina. This was shown principally in the length of time preceding appearance of toxicity in the shoots following their planting in the culture solutions. H 109 was by no means immune, but rather shows notable saline toxicity under the conditions of this experiment, which may not hold true under soil conditions.

The sulphate cultures gave somewhat similar results in that there was notable toxicity in high concentrations and less resistance in Lahaina as compared to H 109. In this series little or no chlorosis developed and there was an entire absence of the striping of the leaves, as shown in the chloride cultures.

On the basis of this preliminary experiment a range of concentration varying from 500 to 4,000 parts per million chlorine was selected. It appeared to be the better plan to have all cultures containing equal parts of chlorine from the different bases. For this, stock solutions containing 100 grams chlorine per litre were made up of sodium chloride, magnesium chloride, calcium chloride and potassium chloride. Also, solutions of sodium sulphate, magnesium sulphate and potassium sulphate were made up containing 100 grams of SO_4 per litre. From these, by proper dilution, five different concentrations were used, each containing the nutrient solution previously described, and were as follows:

1. Nutrient solution plus 4,000 parts per million chlorine.
2. Nutrient solution plus 3,000 parts per million chlorine.
3. Nutrient solution plus 2,000 parts per million chlorine.
4. Nutrient solution plus 1,000 parts per million chlorine.
5. Nutrient solution plus 500 parts per million chlorine.

A similar series was prepared for the sulphates, except that the most dilute, namely, 500 parts per million, was omitted. Also, a set of cultures was prepared in which the three chlorides, calcium, magnesium and sodium were combined in the same ratio as found in the analysis of the soil solution from the soil used in the pot experiment.

The Lahaina and H 109 shoots were prepared as previously described. The plants were grown in 250 cc. wide mouth bottles, wrapped in black paper, and the nutrient solution changed once each week. The original height of the shoot used materially influences the results obtained in comparative toxicity studies. For this reason, while it was not possible to obtain all shoots on the same day, they were all selected of as nearly the same height as possible. It was originally intended to carry the Lahaina and H 109 plants at the same time, and seed pieces were planted accordingly for obtaining the shoots. The H 109 failed to germinate in sufficient number to supply the requirements, so that it was necessary to to carry the experiment in two parts. The Lahaina shoots were started March 2-6, and the H 109 April 30 to May 4. The experiments were carried out in two duplicate sets, in one of which the roots were germinated in tap water and grown to a length of one-half to one inch before placing in the chloride culture. In the second the shoots were started immediately in the culture solutions, or before the roots had germinated. All photographs show plants after having grown for one month in the culture solutions.

Sodium Chloride Cultures: Four days after placing the Lahaina shoots in the sodium chloride cultures the effect was apparent both in the chlorotic appearance of the leaves and a crooked or "hooked" root system in all except the solution containing 500 parts per million chlorine. In the same period of time there

was little or no appearance of chlorosis in H 109, and far less crooked roots, but stunted growth was evident as compared with the control. H 109, in other words, failed to show the outward appearance of the effect of this salt as did the Lahaina. The condition of the plants at the end of the one month period is shown in Figs. 3 and 3A. At 4,000 parts per million H 109 made better growth of both roots and tops. There is little difference at 3,000, 2,000, 1,000 and 500, as far as can be shown by photograph, other than the drooping tops in the Lahaina and the better top growth of Lahaina at 1,000 and 500 p.p.m. On the whole, there was less top injury in Lahaina and less root injury in H 109. The secondary roots were longer on the H 109 plants. At the one month period a chlorotic condition was quite noticeable in the H 109 plants, showing itself in the form of a bleached condition in stripes along the smaller vascular bundles in the leaves.

Calcium Chloride Cultures: In the calcium chloride cultures a disturbance was noted in the 4,000, 3,000 and 2,000 p.p.m. cultures on the Lahaina plants, as shown by chlorosis and crooked roots. In the same period of time no disturbance was noted in the H 109 except in the strongest concentration. As in the sodium chloride cultures the H 109 showed less chlorosis throughout. On the other hand, in the calcium chloride the H 109 showed the earliest distress. At the end of the one month period, at which time the plants were photographed, Figs. 4 and 4A, H 109 had made the better growth in the highest concentrations, and notably better root growth in the lower concentrations. Chlorotic leaf stripes were present on the plants in the 4,000, 3,000, 2,000 and 1,000 p.p.m. solutions.

Magnesium Chloride Cultures: In the magnesium chloride cultures a toxicity toward Lahaina was evident in 4 days' time in the 4,000, 3,000, and 2,000 p.p.m. cultures. As in the other series, during the early stages of the experiment, H 109 failed to show any disturbance other than stunted growth as compared to the checks. As shown in Figs. 5 and 5A, H 109 as compared to Lahaina made better root growth in the three most concentrated culture solutions. There was no leaf striping in this series.

Potassium Chloride Cultures: Some surprising results were obtained in the potassium chloride cultures, showing a striking toxicity of this salt toward H 109. In the Lahaina series there was little toxic action toward the roots, although the tops were greatly stunted, and in some cases dead in the two highest concentrations. This was the only chloride in which a good growth of secondary roots was obtained with the Lahaina. In the H 109 series the plants showed early toxic effects from the K Cl at these concentrations, and at the end of one month all plants were dead in the 4,000, 3,000, and 2,000 p.p.m. cultures, although there was fair root growth at 2,000 p.p.m. The comparative growth is shown in Figs. 6 and 6A.

Mixed Chloride Cultures: The results obtained in this series are significant and indicative of the different effects of high chloride concentrations in the field upon the growth of Lahaina and H 109. With the possible exception of the sodium chloride series the combined chlorides showed greater toxicity toward Lahaina than any chloride singly. This was especially true with the rapidity in which the plants succumbed to the highest concentrations. Four days after placing the shoots in the culture solutions toxicity was evident in all Lahaina plants. On the other hand, with H 109 this series was by far the healthiest set of plants in the entire experiment, with the possible exception of the potassium sulphate set. Little toxicity was evident even at 4,000 and 3,000 p.p.m. The poorest plants were obtained in the solutions containing 2,000 p.p.m. chloride. The most significant difference was in the top growth which, in the preceding series, it will be noted was most often affected (see Figs. 7 and 7A).

Magnesium Sulphate Series: Magnesium sulphate showed notably less toxicity toward Lahaina than the chloride. Injury appeared principally in the tops, which were badly stunted in growth by the high concentration of salt. Secondary root growth was fairly good in this series. On the other hand, this salt appeared to be more toxic toward H 109 than Lahaina. The secondary roots were markedly stunted as compared to the Lahaina roots. There was little or no chlorosis in this series as compared to the magnesium chloride. These cultures are shown in Figs. 8 and 8A.

Sodium Sulphate Series: Of the sulphates, sodium sulphate produced the greatest injury to the Lahaina. This was shown in an almost entire absence of roots in the 4,000 p.p.m. culture and the marked wilting of the tops in the entire series. At 1,000 p.p.m. there were good secondary roots. In the H 109 plants there was better root and top growth at 4,000 p.p.m., but in the rest of the series root development was more greatly retarded in the H 109. The color of the tops in spite of the notable stunted growth was practically normal. The comparative growth is shown in Figs. 9 and 9A.

Potassium Sulphate Cultures: Potassium sulphate in all the concentrations used in this series had little or no effect upon the development of the roots in either variety during the one month period of the experiment. Also, there was little or no effect on the top growth of the H 109, in striking contrast to the potassium chloride series. The Lahaina tops were slightly chlorotic and wilted, but not greatly stunted in growth. It is of interest to compare the growth of both varieties in the potassium sulphate and chloride series. These salts illustrate more clearly than the others the comparative toxicity of the sulphate and chloride radicals. The potassium sulphate series are shown in Figs. 10 and 10A.

While it is recognized that certain limitations must be placed on the interpretation of results obtained in water culture experiments when applying the results to field conditions, it is believed that in the comparative behavior of H 109 and Lahaina in the mixed chloride cultures there lies the cause of the difference in fertility of highly saline soils when cropped to these two varieties. That is to say, H 109 possesses a greater selective power than Lahaina, has the property to withstand greater concentrations of chlorides in its cell sap, or is more greatly favored by antagonism. This difference in selective power of plants and varieties, and

Fig. 3. Showing effect of sodium chloride on growth of Lahaina variety (1 month).

Left to right: 1. Control—nutrient solution. 2. Nutrient + sodium chloride (4,000 p.p.m. Cl). 3. Nutrient + sodium chloride (3,000 p.p.m. Cl). 4. Nutrient + sodium chloride (2,000 p.p.m. Cl). 5. Nutrient + sodium chloride (1,000 p.p.m. Cl). 6. Nutrient + sodium chloride (500 p.p.m. Cl).

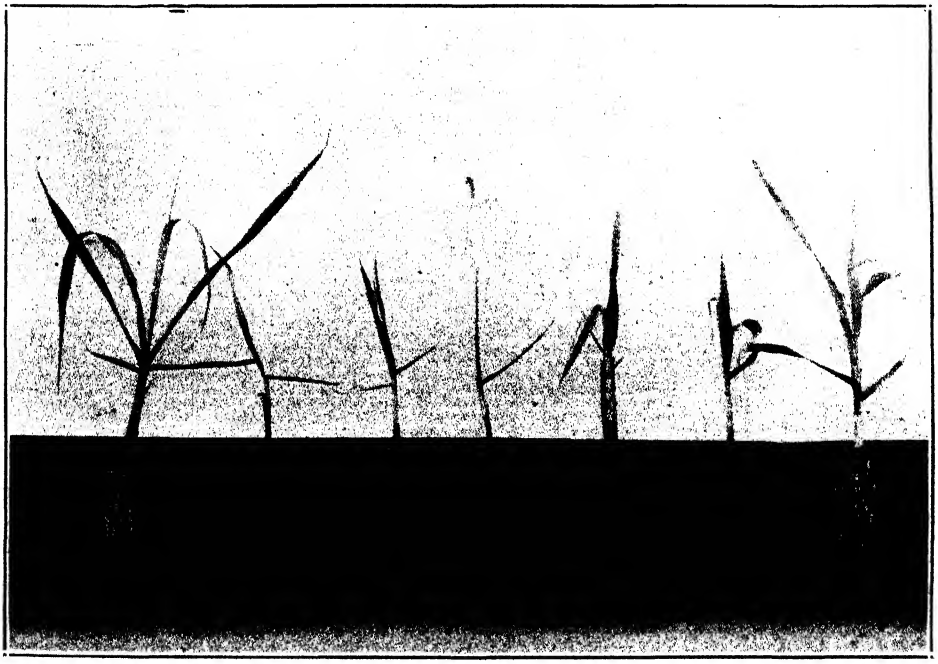

Fig. 3A. Showing effect of sodium chloride on growth of H 109 variety (1 month).

Left to right: 1. Control—nutrient only. 2. Nutrient + sodium chloride (4,000 p.p.m. Cl). 3. Nutrient + sodium chloride (3,000 p.p.m. Cl). 4. Nutrient + sodium chloride (2,000 p.p.m. Cl). 5. Nutrient + sodium chloride (1,000 p.p.m. Cl). 6. Nutrient + sodium chloride (500 p.p.m. Cl). 7. Control—nutrient only.

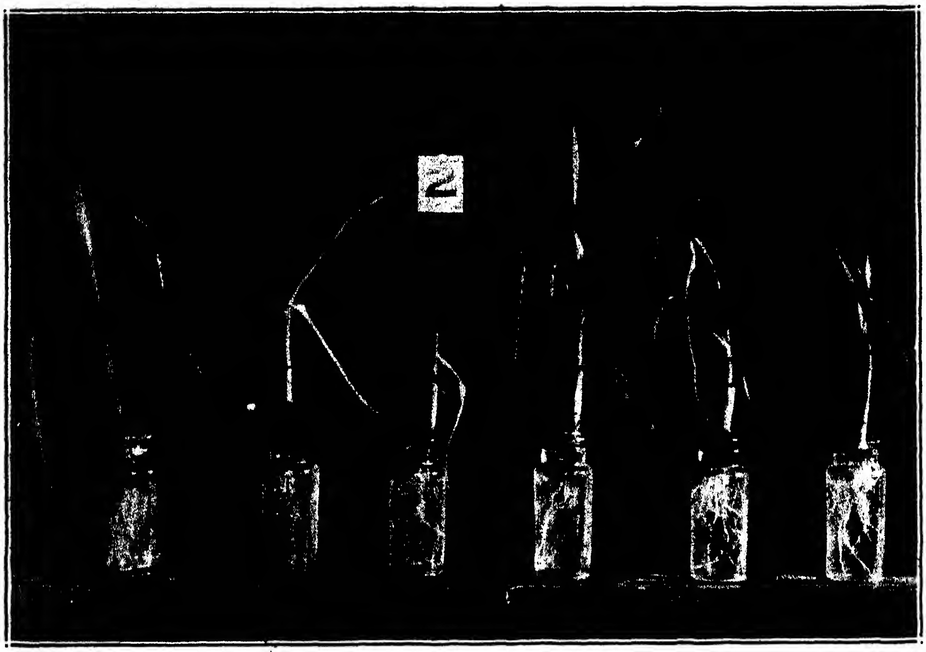

Fig. 4. Showing effect of calcium chloride on growth of Lahaina variety (1 month). Left to right: 1. Control—nutrient solution. 2. Nutrient + calcium chloride (4,000 p.p.m. Cl). 3. Nutrient + calcium chloride (3,000 p.p.m. Cl). 4. Nutrient + calcium chloride (2,000 p.p.m. Cl). 5. Nutrient + calcium chloride (1,000 p.p.m. Cl). 6. Nutrient + calcium chloride (500 p.p.m. Cl).

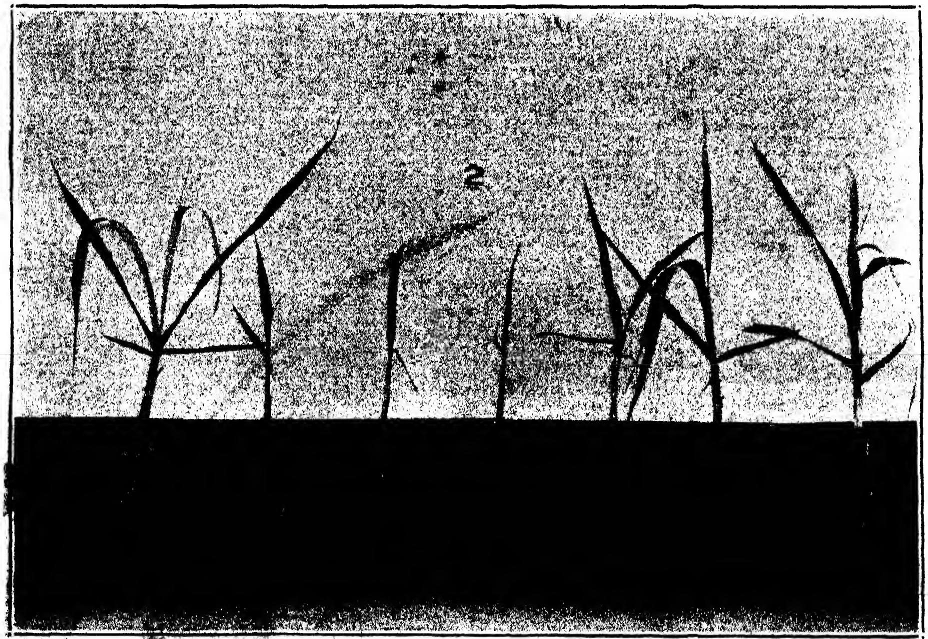

Fig. 4A. Showing effect of calcium chloride on growth of H 109 variety (1 month).

Left to right: 1. Control—nutrient solution. 2. Nutrient + calcium chloride (4,000 p.p.m. Cl). 3. Nutrient + calcium chloride (3,000 p.p.m. Cl). 4. Nutrient + calcium chloride (2,000 p.p.m. Cl). 5. Nutrient + calcium chloride (1,000 p.p.m. Cl). 6. Nutrient + calcium chloride (500 p.p.m. Cl). 7. Control—nutrient only.

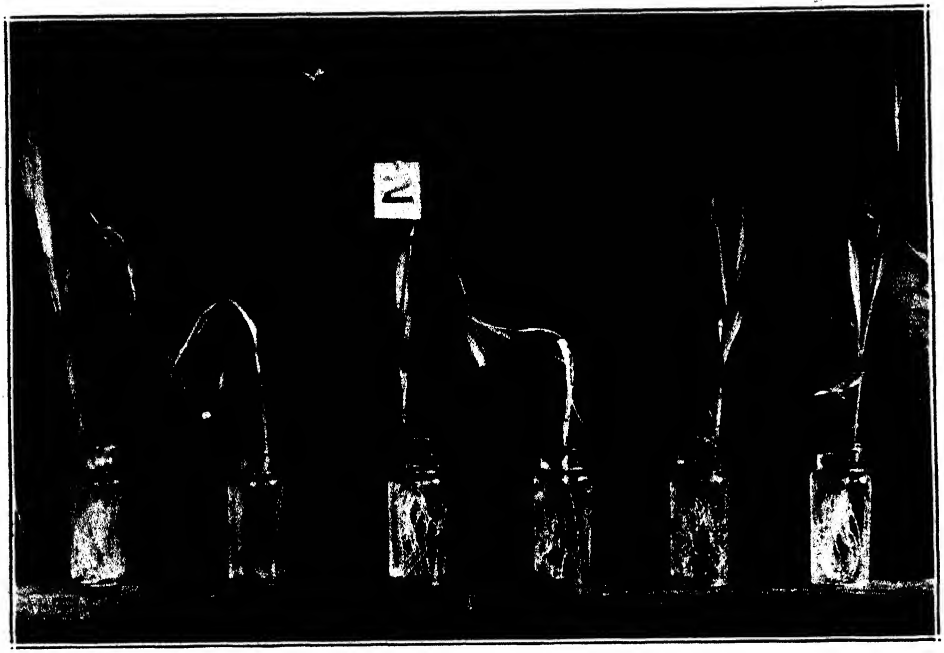

Fig. 5. Showing effect of magnesium chloride on growth of Lahaina variety (1 month).

Left to right: 1. Control—nutrient solution. 2. Nutrient + magnesium chloride (4,000 p.p.m. Cl). 3. Nutrient + magnesium chloride (3,000 p.p.m. Cl). 4. Nutrient + magnesium chloride (2,000 p.p.m. Cl). 5. Nutrient + magnesium chloride (1,000 p.p.m. Cl). 6. Nutrient + magnesium chloride (500 p.p.m. Cl).

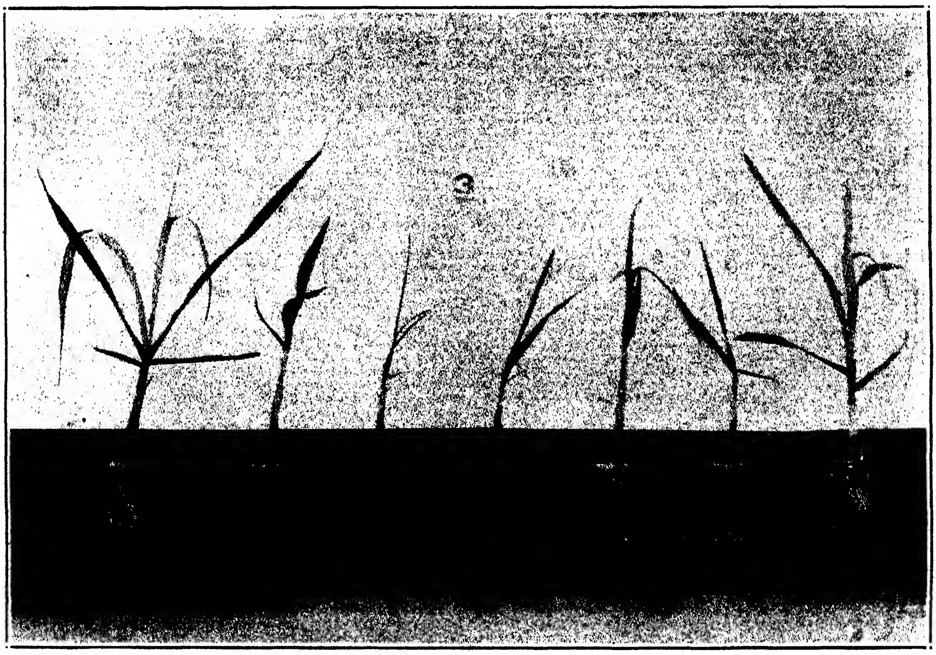

Fig. 5A. Showing effect of magnesium chloride on growth of H 109 variety (1 month).

Left to right: 1. Control—nutrient only. 2. Nutrient + magnesium chloride (4,000 p.p.m. Cl). 3. Nutrient + magnesium chloride (3,000 p.p.m. Cl). 4. Nutrient + magnesium chloride (2,000 p.p.m. Cl). 5. Nutrient + magnesium chloride (1,000 p.p.m. Cl). 6. Nutrient + magnesium chloride (500 p.p.m. Cl). 7. Control—nutrient only.

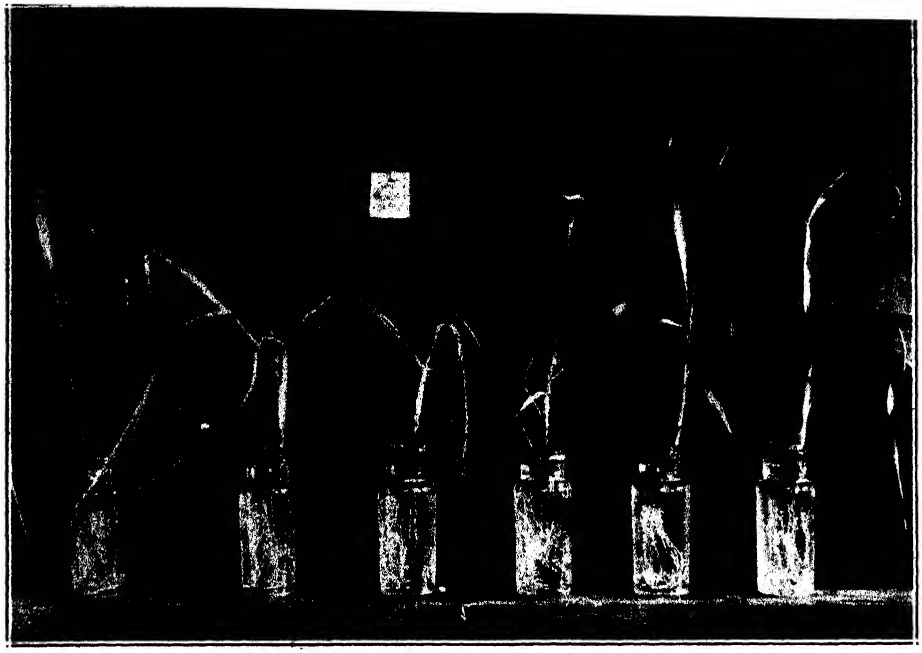

Fig. 6. Showing effect of potassium chloride on growth of Lahaina variety (1 month).

Left to right: 1. Control—nutrient solution. 2. Nutrient + potassium chloride (4,000 p.p.m. Cl). 3. Nutrient + potassium chloride (3,000 p.p.m. Cl). 4. Nutrient + potassium chloride (2,000 p.p.m. Cl). 5. Nutrient + potassium chloride (1,000 p.p.m. Cl). 6. Nutrient + potassium chloride (500 p.p.m. Cl).

Fig. 6A. Showing effect of potassium chloride on growth of H 109 variety (1 month).

Left to right: 1. Control—nutrient solution. 2. Nutrient + potassium chloride (4,000 p.p.m. Cl). 3. Nutrient + potassium chloride (3,000 p.p.m. Cl). 4. Nutrient + potassium chloride (2,000 p.p.m. Cl). 5. Nutrient + potassium chloride (1,000 p.p.m. Cl). 6. Nutrient + potassium chloride (500 p.p.m. Cl). 7. Control—nutrient only.

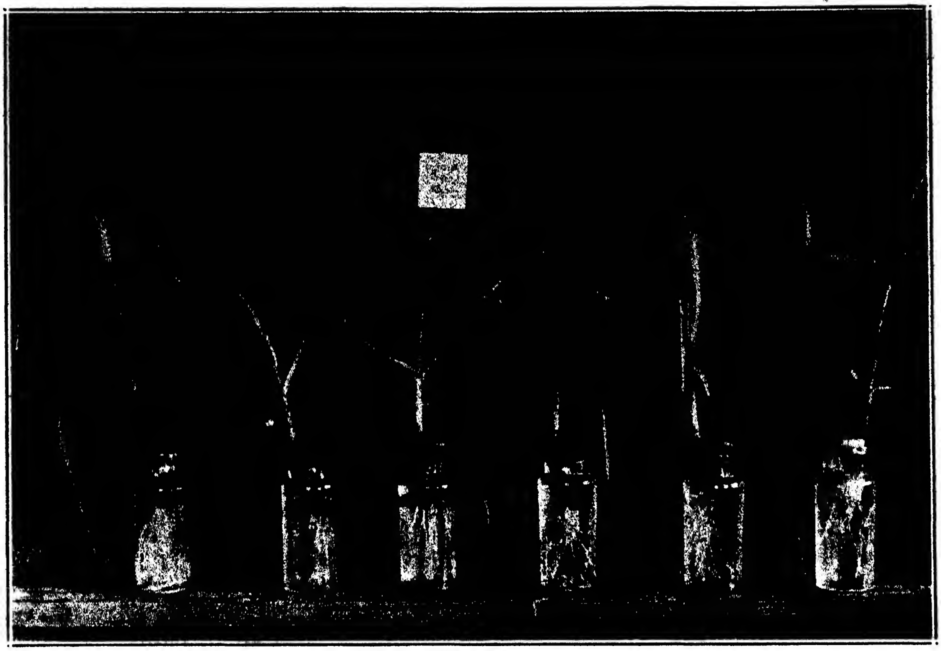

Fig. 7. Showing effect of mixed chlorides of sodium, calcium and magnesium on growth of Lahaina variety (1 month).

Left to right: 1. Control—nutrient only. 2. Nutrient + chlorides (4,000 p.p.m. Cl). 3. Nutrient + chlorides (3,000 p.p.m. Cl). 4. Nutrient + chlorides (2,000 p.p.m. Cl). 5. Nutrient + chlorides (1,000 p.p.m. Cl). 6. Nutrient + chlorides (500 p.p.m. Cl).

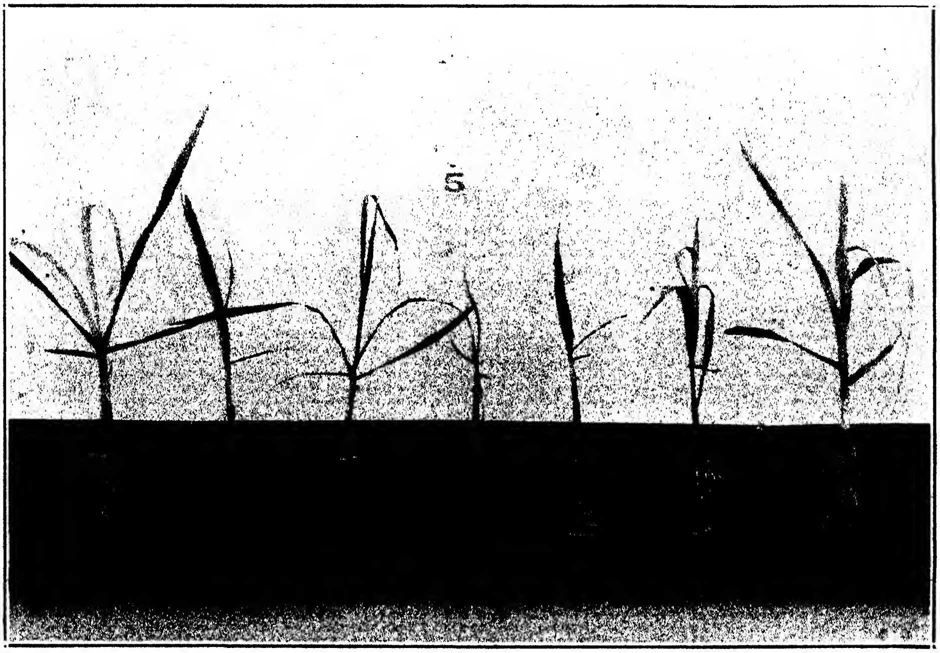

Fig. 7A. Showing effect of mixed chlorides of sodium, calcium and magnesium on growth of H 109 variety (1 month).

Left to right: 1. Control—nutrient only. 2. Nutrient + chlorides (4,000 p.p.m. Cl). 3. Nutrient + chlorides (3,000 p.p.m. Cl). 4. Nutrient + chlorides (2,000 p.p.m. Cl). 5. Nutrient + chlorides (1,000 p.p.m. Cl). 6. Nutrient + chlorides (500 p.p.m. Cl). 7. Control—nutrient only.

Fig. 8. Showing effect of magnesium sulphate on growth of Lahaina variety (1 month).

Left to right: 1. Control—nutrient solution. 2. Nutrient + magnesium sulphate (4,000 p.p.m. SO_4). 3. Nutrient + magnesium sulphate (3,000 p.p.m. SO_4). 4. Nutrient + magnesium sulphate (2,000 p.p.m. SO_4). 5. Nutrient + magnesium sulphate (1,000 p.p.m. SO_4).

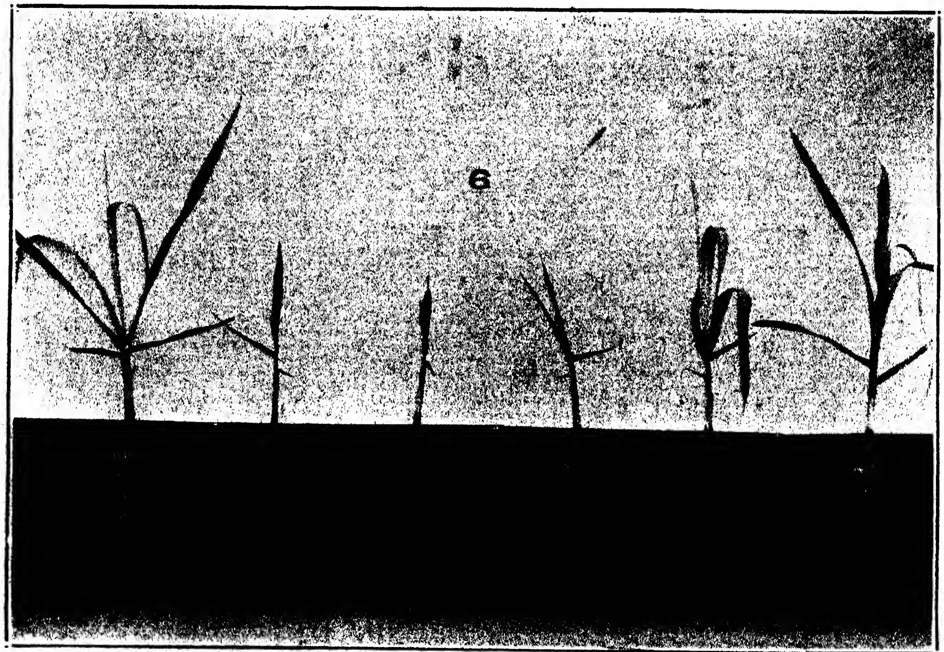

Fig. 8A. Showing effect of magnesium sulphate on growth of H 109 variety (1 month).

Left to right: 1. Control—nutrient only. 2. Nutrient + magnesium sulphate (4,000 p.p.m. SO_4). 3. Nutrient + magnesium sulphate (3,000 p.p.m. SO_4). 4. Nutrient + magnesium sulphate (2,000 p.p.m. SO_4). 5. Nutrient + magnesium sulphate (1,000 p.p.m. SO_4). 6. Control—nutrient only.

Fig. 9. Showing effect of sodium sulphate on growth of Lahaina variety (1 month). Left to right: 1. Control—nutrient solution. 2. Nutrient + sodium sulphate (4,000 p.p.m. SO_4). 3. Nutrient + sodium sulphate (3,000 p.p.m. SO_4). 4. Nutrient + sodium sulphate (2,000 p.p.m. SO_4). 5. Nutrient + sodium sulphate (1,000 p.p.m. SO_4).

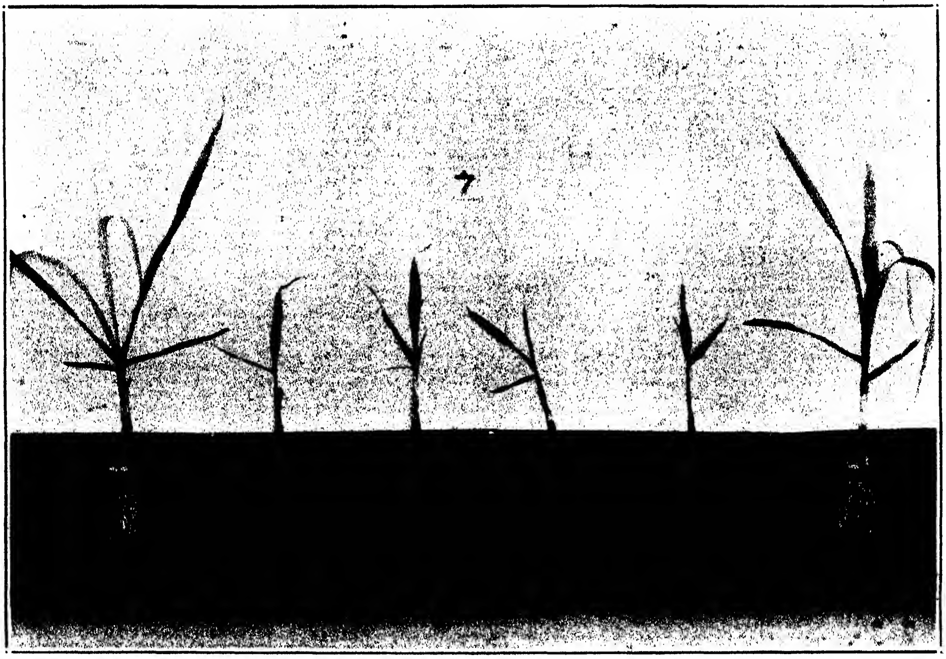

Fig. 9A. **Showing effect of sodium sulphate on growth of H 109 variety (1 month). Left to right: 1. Control—nutrient only. 2. Nutrient + sodium sulphate (4,000 p.p.m. SO_4). 3. Nutrient + sodium sulphate (3,000 p.p.m. SO_4). 4. Nutrient + sodium sulphate (2,000 p.p.m. SO_4). 5. Nutrient + sodium sulphate (1,000 p.p.m. SO_4). 6. Control—nutrient only.**

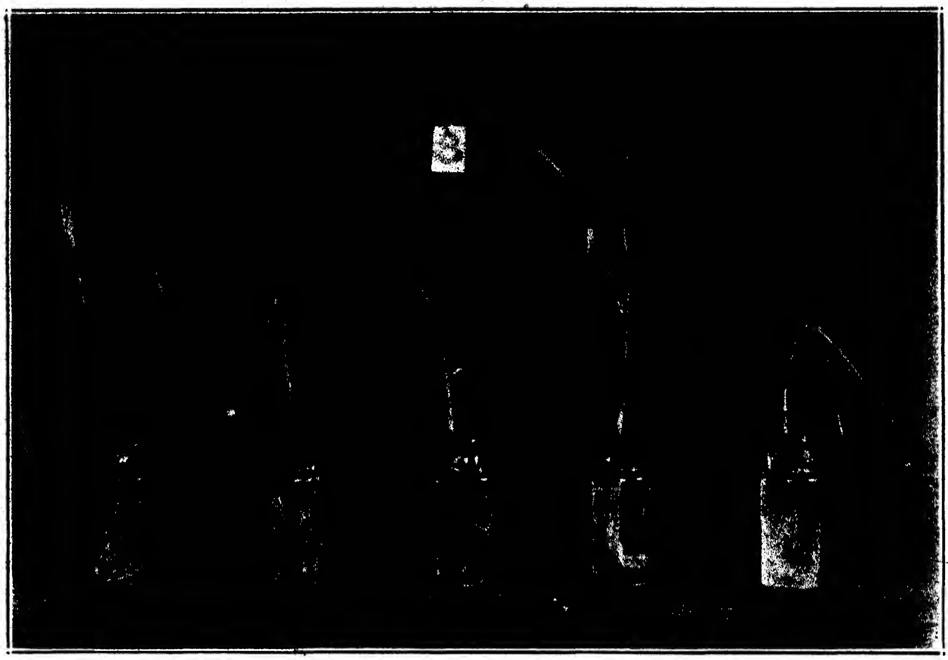

Fig. 10. Showing effect of potassium sulphate on growth of Lahaina variety (1 month).

Left to right: 1. Control—nutrient solution. 2. Nutrient + potassium sulphate (4,000 p.p.m. SO_4). 3. Nutrient + potassium sulphate (3,000 p.p.m. SO_4). 4. Nutrient + potassium sulphate (2,000 p.p.m. SO_4). 5. Nutrient + potassium sulphate (1,000 p.p.m. SO_4).

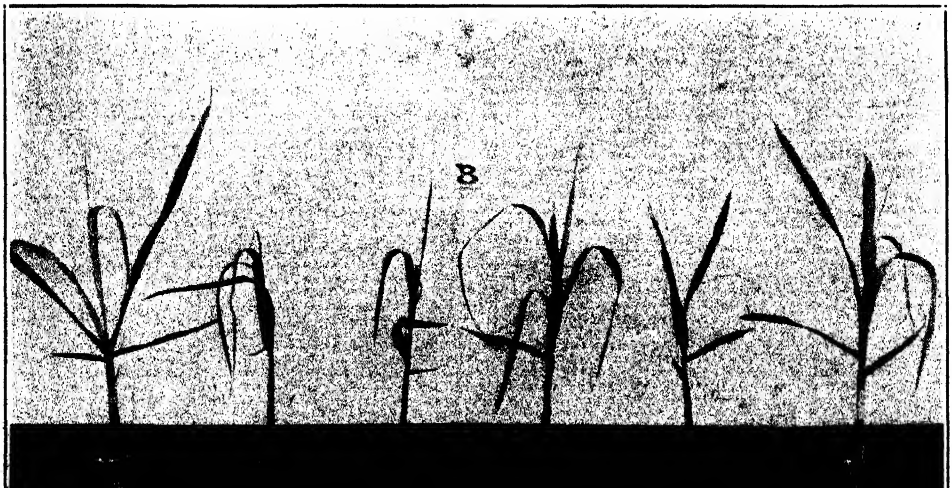

Fig. 10A. Showing effect of potassium sulphate on growth of H 109 variety (1 month).

Left to right: 1. Control—nutrient only. 2. Nutrient + potassium sulphate (4,000 p.p.m. SO_4). 3. Nutrient + potassium sulphate (3,000 p.p.m. SO_4). 4. Nutrient + potassium sulphate (2,000 p.p.m. SO_4). 5. Nutrient + potassium sulphate (1,000 p.p.m. SO_4). 6. Control—nutrient only.

also the antagonism between salts or their acid and basic radicals in entering the roots, has often been noted in plant physiology.

The physiological effects of chlorides have been extensively studied by Osterhout (12), who has shown that ions penetrate living protoplasm and that many ions which penetrate quite rapidly in pure solutions may be hindered or prevented from going in by the addition of small amounts of other salts. For example, calcium chloride, strontium chloride and barium chloride are able to hinder very greatly the entrance of the ions of sodium chloride. The mechanism is not fully understood, but he has noted visible changes in the plasma membrane which are entirely different from those produced by such salts as sodium chloride. He suggests that there is good evidence to show that sodium chloride does not enter the cell alone but is accompanied by calcium chloride. He says that it is possible that these salts may wholly prevent each other from penetrating nuclear membranes, which is of importance in this connection. The antagonistic action of salts is largely or entirely due to the fact that they hinder or prevent one another from entering the protoplasm.

The antagonism between salts has also been studied by Reed and Haas (14) on citrus and walnut seedlings. Nutrients containing toxic amounts of sodium chloride were made less toxic on addition of calcium chloride in spite of the fact that the concentration of the chlorine was increased thereby. They found that orange trees absorb chlorine readily and their growth is characteristically affected by amounts which would be harmless in the case of certain other ions. The effect of sodium chloride on trees growing in soils under control conditions show a restricted growth of roots and shoots, the premature abscission of leaves agreeing with the analyses, which show an increased amount of chlorine absorbed.

Miyake (11), working with rice, also found a marked antagonism in saline solutions and a notable toxicity from chlorides.

The principal function of the root system is absorption of water and inorganic salts. Water enters the plant through the root hairs and passes out principally through the stomata in the surface of the leaves. Thus there is an unbroken stream of water passing through the plant. A number of factors may restrict the rate of flow, and too rapid transpiration or too slow absorption will seriously retard normal development. Among the factors affecting the intake of water by the roots are included the composition and concentration of the soil solution. This process of water intake tends to go on as long as the total concentration of the cell sap of the root hair cells is greater than that of the soil solution surrounding the root hairs. The greater the difference in concentration between the cell sap and the soil solution the more rapid the water movement. If the concentration of the soil solution approaches that of the cell sap the rate of absorption slows down. The roots of plants growing in highly saline soils are often surrounded by a soil solution of sufficiently high concentration to retard absorption. In such cases there may be present plenty of water in the soil, but the plant can secure it only with great difficulty on account of the high concentration of the soil solution. This is often termed a physiological drought and was often observed on Lahaina plants affected by the so-called Lahaina disease on irrigated fields. In fact this was one of the principal characteristics of the affected stools.

In one case we have a physiological inability to absorb water, due to a high salt concentration, while in a physical drought we have an actual moisture deficiency.

The composition of such saline accumulations is also closely involved in the functional processes of absorption. The rate of entrance of a given salt is determined chiefly by its concentration in the cell sap. If the concentration of a given salt in the cell sap is less than the concentration of that same salt in the soil solution then that salt tends to diffuse inwardly. It is thus evident that, depending upon the varietal powers of selection possessed by plant varieties, excessive quantities of undesirable or toxic salts may gain entrance by diffusion into the tissues. Through differences in the character of the cytoplasm membrane many plants possess selective properties. There may be a rapid absorption of some salt, for example, potassium sulphate, while another salt at that time may be entering the root hairs in comparatively much lesser amounts. The quantities of the many salts present in the soil solution required or assimilated by the plant are also to be considered. Whereas salts pass from the soil solution into the roots, with the exception of water and carbon dioxide, these same salts are unable to pass from the roots to the soil solution. It is evident from this that once within the plant non-assimilable salts will often reach sufficient concentration to seriously retard the normal plant processes.

On the whole, the water cultures did not show sufficient differences in the action of the single salts to account for the differences in the growth of Lahaina and H 109 on the highly saline soils. The toxicity toward H 109 was more sluggish than with the Lahaina, but once the plant showed distress it failed rapidly from this point. The difference in growth of these two varieties in fields where saline accumulations have taken place is unquestionably a property of the combined chlorides. In other words, in the presence of the several salts H 109 is able to adapt itself through the possession of a property lacking in the functional processes of the Lahaina variety.

It is of interest in this connection to present the observations of the several plantation managers and the Experiment Station men who have given attention to the Lahaina failure on the irrigated plantations. These are taken from the discussions at the meetings of the H. S. P. A., and from the reports on file at the Experiment Station. Attention is especially called to the many references to and the observations on the improved growth of Lahaina which followed excessive irrigation and heavy rainfalls, which is direct proof of the relation of soluble materials in the soil to the poor growth of Lahaina in these cases.

The first reports on file are those of Lewton-Brain, beginning in October, 1905, in which, while he confined his investigations to the fungi present in the rotted roots, he stated that "a few weeks later with constant large irrigation the cane apparently entirely recovers." Lyon, continuing this work, suggested in 1908 from his observations at Ewa that the "appearance of the Lahaina was not that of an infectious disease but rather of poor drainage." Larsen in a report of February, 1909, in describing the condition of the diseased cane, mentions the dry leaf tips and greater injury along the irrigation ditches, especially those constantly full of water. About this same time Lyon describes the diseased cane as "of that suffering for water."

In the annual report for 1913 Peck mentions having found high alkalinity in some of the soils about diseased stools. This point came up for extensive discussion at the annual meeting of the Association for the same year. The following extracts from this discussion are of interest. Peck had installed extensive experiments in a diseased area at Waipio: "Unfortunately, for our experiments, the weather conditions have been such that all the cane has come along beautifully in the last six months. Cane which was given up has, we have discovered, grown to normal cane." During this discussion James Gibb, referring to this recovery, made the following significant statement: "In May or June we had a heavy rain. We had *six inches* of rain in *24 hours,* and later there was a lighter rain amounting to about *four inches.* I do not know, but I offer it as a possible explanation of how it came about, and I would like to ask if that was not the experience at the Station. I just speak of that unusual rainfall which might have brought about that condition. I know our cane came up very rapidly." Gibb's observations were fully confirmed during this discussion by Agee.

During this discussion Mr. Renton stated: "I think it is a question of too wet or too dry and something in the nature of the soil." In the wet soil near the ditches there would be high concentration of salt from the continuous supply, while in the dry soil concentration would result from evaporation.

At the 1914 annual meeting of the Association the Lahaina failure again came up for discussion.

H. P. Agee: There seems to be a serious thing in connection with this trouble; while the other varieties are so much more resistant to the trouble than the Lahaina, yet there are instances where the seedlings succumb to the same condition, but in a very much less degree than the Lahaina variety. Whether it is a question of *brackish water,* which fresh water will overcome, we cannot say.

J. F. C. Hagens: Is it not only on the lands irrigated with artesian water?

H. P. Agee: The symptoms are not definite enough to say that. It is true that the worst trouble is where artesian water is being applied. . . .

In 1915, Speare made an extensive survey of the affected fields at Honolulu Plantation and Oahu Sugar Company. The following observations are significant:

Oahu Sugar Company: Both mauka and makai fields are affected. Almost invariably the disease is more intense and first appears in connection with the watercourses, level ditches and straight ditches. If in connection with a level ditch, the cane appears in bad condition below it and good above it. It will thus run along the makai side of the ditch for some distance and then after a time appear on the mauka side, after which it spreads more rapidly. The cause is *augmented by pump water.*

Honolulu Plantation: The disease was worst in the high coral fields around Puuloa. "One striking exception is apparent in Field 17 where an area one watercourse in width is in good cane though surrounded by diseased cane. *This small area receives night water from the mill in distinction from the neighboring areas.*"

Burgess, like Peck, noted excessive alkalinity in some soils about infected stools and made a very intensive study of the toxicity of "Black" alkali toward cane. His investigations very strongly indicated that this form of alkali may, in many

of the irrigated fields, be associated with their low fertility. It is of interest to note in his experiments that there was less disease during the years of heaviest rainfall and that the disease occurred mostly in sections where the rainfall was less than 20 inches per year.

Conclusions

1. On the irrigated plantations there is shown to be a greater accumulation of saline material in many fields where Lahaina failed than where this variety is still making good growth. It is by no means suggested or contended that saline accumulation was the only cause of Lahaina failure on all the fields of the irrigated plantations, but rather to show that in many fields it has reached a toxic concentration for this variety and was instrumental or a contributing agent in the failure of this variety in many cases.

2. The growth of Lahaina is greatly increased in these soils by heavy irrigation. This is shown by the pot experiments and by the several references to observations on the effect of heavy rainfalls on the increased fertility of such fields during the period that "Lahaina disease" was at its worst.

3. It was shown by water cultures, using high concentrations of single salts, that there was a marked toxicity to both the Lahaina and H 109 under the conditions of the experiment. While these salts singly were in most cases slightly more toxic toward Lahaina, the difference was not sufficient to account for the wide differences in the growth of these two varieties in the fields where large amounts of salt have accumulated.

4. By growing Lahaina and H 109 in cultures to which instead of adding the salts singly they were added together in approximately the same ratio in which they are found in the field, there was shown a far greater toxicity toward Lahaina. It is believed that this experiment shows quite conclusively that the unlike growth of these two varieties on the highly saline soils is due either to a basic antagonism or a greater selective power of resistance in the H 109 variety.

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The Prevalence of Nut Grass on Island Soils as Influenced by Soil Reaction

By W. T. McGeorge

During the course of our investigations on the fertility of the acid plantation soils, the writer made the observation that nut grass (*Cyperus rotundus*) was notably absent or made very poor growth on such types. The question arose, naturally, as to the underlying causes of this characteristic of nut grass and its possibility as a control measure on a field scale; that is, what is the constituent of acid soils which is toxic toward nut grass, and can it be produced in the field by the application of chemicals?

As has been pointed out in previous articles in the *Record*, Island soils contain soluble aluminum which is known to be toxic toward many plants. Experiments were therefore planned to determine whether the toxicity toward nut grass was the acidity itself, the salts of aluminum, or some hitherto unidentified agent. The

experimental procedure involved growing this plant in water cultures to which sulphuric acid and aluminum salts had been added.

Water Cultures

Nutrient Solution: The following nutrient solution was used in the water cultures:

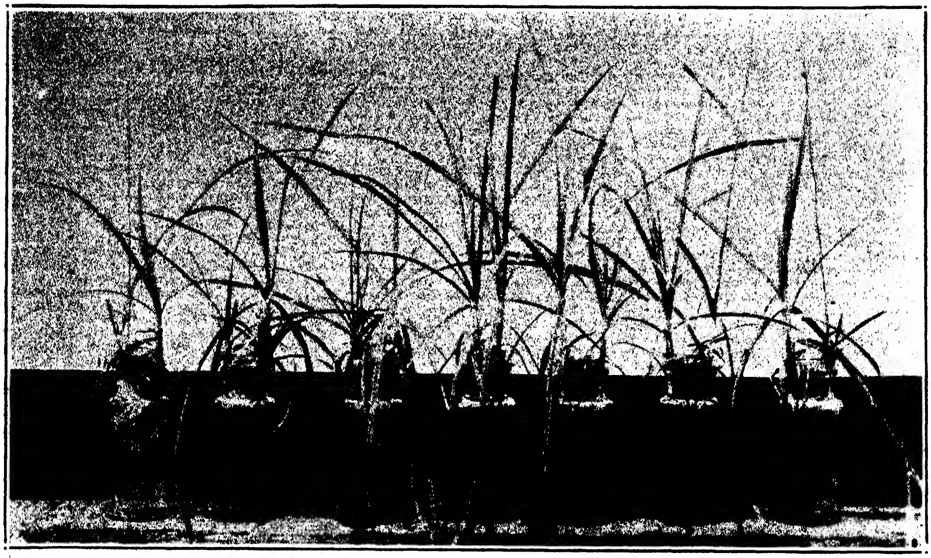
.2 N Calcium nitrate	15 cc. per litre
.1 N Ammonium nitrate	10 " " "
.1 N Potassium chloride	8 " " "
.2 N Magnesium sulphate	8 " " "
8.3 gms. Calcium phosphate per litre	5 " " "
Ferric citrate	trace

Using the above nutrient solution as a basis, two sets of cultures were prepared. To one set was added increasing amounts of aluminum chloride. To the second set sulphuric acid was added in amounts sufficient to produce the same range of acidity or hydrogen ion concentration as obtained in the aluminum cultures. The plan was as follows:

1.	Control-nutrient solution only	pH 6.8
2.	Nutrient 4 cc. .2 N aluminum chloride	" 4.3
3.	" 6 cc. " " "	" 4.0
4.	" 8 cc. " " "	" 4.0
5.	" 10 cc. " " "	" 4.0
6.	" 25 cc. " " "	" 4.0
7.	" sulphuric acid to give	" 6.4
8.	" " " " "	" 5.6
9.	" " " " "	" 5.2
10.	" " " " "	" 4.6
11.	" " " " "	" 4.2
12.	" " " " "	" 3.9

Healthy young plants about 4 inches in height were obtained from the Experiment Station grounds where nut grass grows in profusion for use in these cultures. One-half of the plants were taken with the bulb or "nut" attached and one-half without. The plants were suspended in 250 cc. wide mouth bottles containing the above solutions, by means of a cork with slots extending in toward the center, as shown in the illustrations.

The plants were started in the cultures on September 12, and were photographed, as shown in Fig. 1, on October 13. These cultures show quite conclusively that the toxic constituent of acid soils retarding the growth of nut grass is not the acidity of the soil or hydrogen ion concentration *per se*. As a matter of fact the growth of nut grass was greatly stimulated by the acid. On the other hand, the plants in the solutions to which aluminum chloride was added while they remained alive in all cases, there was absolutely no root growth and no further growth of tops over the original height.—It seems fair to interpret from this that aluminum is the growth retarding constituent of acid Island soils so far as nut grass is concerned. On October 18, the plants in this experiment were



Nut grass in water cultures + sulphuric acid.

Left to right: 1. Control—nutrient solution. 2. Nutrient solution + sulphuric acid to pH 6.4. 3. Nutrient solution + sulphuric acid to pH 5.6. 4. Nutrient solution + sulphuric acid to pH 5.2. 5. Nutrient solution + sulphuric acid to pH 4.6. 6. Nutrient solution + sulphuric acid to pH 4.2. 7. Nutrient solution + sulphuric acid to pH 3.8.

Nut grass in water cultures + aluminum chloride.

Left to right: 1. Control—nutrient solution. 2. Nutrient solution + 4 cc. .2N aluminum chloride pH 4.3. 3. Nutrient solution + 6 cc. .2N aluminum chloride pH 4.0. 4. Nutrient solution + 8 cc. .2N aluminum chloride pH 4.0. 5. Nutrient solution +10 cc. .2N aluminum chloride pH 4.0. 6. Nutrient solution + 25 cc. .2N aluminum chloride pH 4.0.

Fig. 1

reversed, that is, the large plants from the acid cultures were transferred to the aluminum and vice versa. The root tips of the plants from the former in a few days after changing to the aluminum chloride nutrient solutions became brown and discolored and there was a notable chlorosis (yellow) and premature dying of the leaves.

The "dormant" plants from the aluminum cultures on changing to the acid nutrient soon sent out roots and started to grow and, while stunted, as compared to the check plants, made a good growth.

Pot Experiments

In view of the above, a series of soil treatments was planned involving the application of fertilizer compounds of a residual acidity. Ammonium sulphate, sulphur and aluminum chloride were chosen as three such materials. Pots containing 10 lbs. soil were used and were filled with soil from the Makiki Plots. This soil is alkaline in reaction and very highly buffered, that is to say, it resists strongly the effect of acid fertilizers in its reaction. The following table gives in detail the plan of the experiment:

ALUMINUM CHLORIDE SERIES

1.	Soil untreated						
2.	17 grams	Aluminum	chloride	added	(approx.	6	t.p.a.)
3.	28	"	"	"	"	9	"
4.	39	"	"	"	"	13	"
5.	55	"	"	"	"	18	"

SULPHUR SERIES

	Soil untreated					
2.	25.5 gms.	Sulphur	added	(approx.	8	t.p.a.)
3.	50	"	"	"	16	"
4.	100	"	"	"	32	"
5.	200	"	"	"	64	"
6.	300	"	"	"	128	"

AMMONIUM SULPHATE SERIES

1.	Soil untreated						
2.	12.5 gms.	Ammonium	sulphate	added	(approx.	4	t.p.a.)
3.	25	"	"	"	"	8	"
4.	50	"	"	"	"	16	"
5.	100	"	"	"	"	32	"
6.	200	"	"	"	"	64	"
7.	300	"	"	"	"	128	"

The above treatments were made on November 16, and the pots watered daily in order to germinate the nut grass nodules transferred to the pots with the soil and to allow time for the action of the chemicals before making the test. On February 5, the plants were removed from the pots and samples of soil were taken from each in order to determine the change in reaction produced by the chemicals. The pots were then immediately replanted with also a series of Ber-

muda grass merely for comparative purposes. The soil reactions are given in the following table:

TABLE 1

Pot No.	Aluminum Chloride	Sulphur	Ammonium Sulphate
1	8.01	8.01	8.01
2	7.67	5.13	7.84
3	7.33	4.71	7.42
4	7.33	4.63	6.74
5	7.08	4.46	5.81
6	....	4.46	4.97
7	....	....	4.38

This data shows the great resistance in this type of soil to acid fertilizers in that the aluminum chloride up to 18 tons per acre had little effect on the reaction. The same may be said of ammonium sulphate, where in excess of 32 tons per acre was required to give a toxic acidity. Sulphur showed the greatest residual acidity, the lowest application, namely, 8 tons per acre, producing a reaction of pH 5.13.

The plants were photographed April 27, and their condition at that time is shown in Fig. 2.

Aluminum Chloride: There being no production of acidity from the application of aluminum chloride, no toxicity was shown. This is in line with our investigation of aluminum toxicity in that a certain degree of acidity must be present in the soil to allow the solubility of the aluminum in the soil solution. As previously stated, this soil is very highly buffered and capable of throwing large quantities of aluminum out of solution into ineffective combinations.

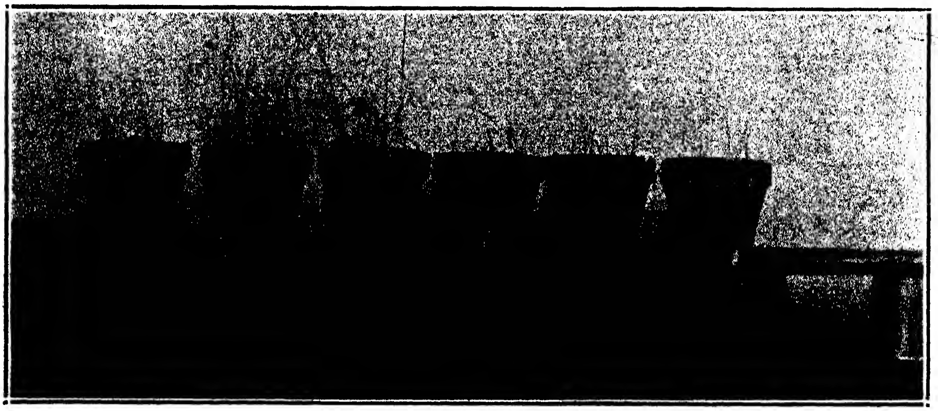
Sulphur: This material was much more effective. A marked increase in acidity was obtained and likewise on increasing the acidity toxicity toward nut grass resulted. At the time the pots were photographed the plants in the last three were dead. Later on the other two pots became badly discolored also and there was little sign of life in the tops.

Ammonium Sulphate: In Table 1 it will be seen that the last two treatments produced a sufficient acidity to be toxic, yet no toxicity was shown at the time the plants were photographed. However, one month later the plants in the two pots receiving the highest applications were yellow and showed no signs of life.

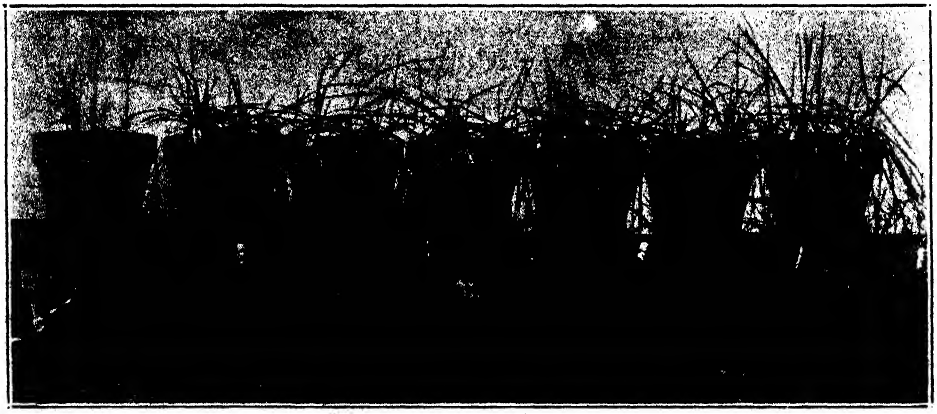
This little experiment shows that in such a soil type as this any practical control of nut grass through soil reaction is out of the question unless over an extended period of applying ammonium sulphate or sulphur. In such highly buffered soils too large applications of chemicals would be required.

In view of the fact that this soil type is rarely found on plantations this experiment was repeated using a red clay, a very widely distributed type and one which is low in phosphates and other buffer agents. The plan of this experiment was similar to that with the Makiki soils in that 10 lbs. soil were used. On the other hand, knowing the different properties of this type smaller applications of chemicals were made. The following is the plan of this experiment:

Left to right: 1. Control—no treatment. 2. 10 lbs. soil + 17 grams aluminum sulphate. 3. 10 lbs. soil + 28 grams aluminum sulphate. 4. 10 lbs. soil + 39 grams aluminum sulphate. 5. 10 lbs. soil + 55 grams aluminum sulphate.



Left to right: 1. Control—no treatment. 2. 10 lbs. soil + 25 grams sulphur. 3. 10 lbs. soil + 50 grams sulphur. 4. 10 lbs. soil + 100 grams sulphur. 5. 10 lbs. soil + 200 grams sulphur. 6. 10 lbs. soil + 300 grams sulphur.



Left to right: 1. Control—no treatment. 2. 10 lbs. soil + 12.5 grams ammonium sulphate. 3. 10 lbs. soil + 25 grams ammonium sulphate. 4. 10 lbs. soil + 50 grams ammonium sulphate. 5. 10 lbs. soil + 100 grams ammonium sulphate. 6. 10 lbs. soil + 200 grams ammonium sulphate. 7. 10 lbs. soil + 300 grams ammonium sulphate.

Fig. 2

Nut grass top row—Bermuda grass bottom row. Makiki soil.

ALUMINUM CHLORIDE

1. Untreated soil
2. 15 grams aluminum chloride per pot (approx. 3.3 t.p.a.)
3. 25 " " " " " " 5.5 "
4. 35 " " " " " " 7.7 "

SULPHUR

1. Untreated soil
2. 5 grams sulphur per pot (approx. 1.1 t.p.a.)
3. 10 " " " " " 2.2 "
4. 20 " " " " " 4.4 "
5. 40 " " " " " 8.8 "
6. 60 " " " " " 13.2 "

AMMONIUM SULPHATE

Untreated soil
2. 5 grams ammonium sulphate per pot (approx. 1.1 t.p.a.)
3. 10 " " " " " " 2.2 "
4. 20 " " " " " " 4.4 "
5. 40 " " " " " " 8.8 "
6. 60 " " " " " " 13.2 "

The chemicals were applied to the soil on April 3, and nut grass planted April 15. The plants were photographed on May 29.

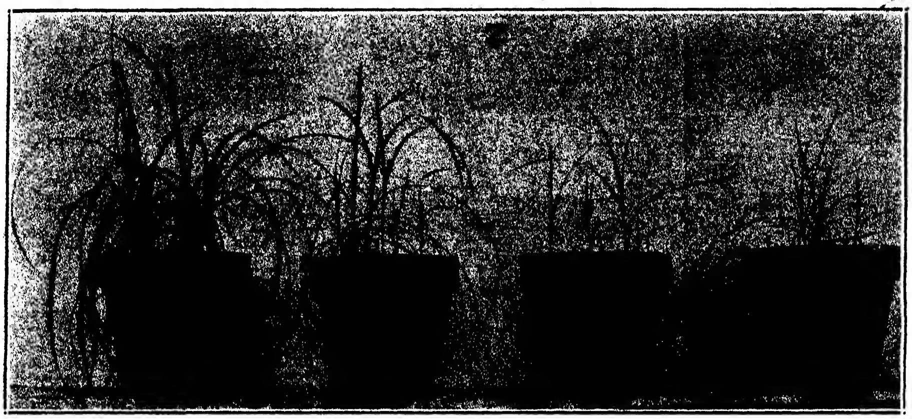
A sample of soil was taken from each pot for a determination of the soil reaction. The results are given in the following table:

Pot No.	Sulphur	Ammonium Sulphate	Aluminum Chloride
1	7.42	7.42	7.42
2	5.98	6.83	6.06
3	5.90	6.91	5.81
4	5.30	6.83	5.30
5	4.97	6.57	....
6	4.88	6.74	....

The soil in each pot was then well mixed, returned to the pots and replanted to nut grass on June 1. This set of plants was continued until July 29, when the plants were photographed and the reaction of the soil again determined. The reactions are given in the following table:

Pot No.	Sulphur	Ammonium Sulphate	Aluminum Chloride
1	7.67	7.67	7.67
2	5.90	7.92	6.15
3	5.81	7.50	6.74
4	4.80	7.33	5.80
5	3.71	7.00	....
6	3.28	7.00	....

The condition of the plants in the first planting is shown in Fig. 3, while only the sulphur series of the second planting is shown in Fig. 4.



Left to right: 1. Control—no treatment. 2. 10 lbs. soil + 15 grams aluminum chloride. 3. 10 lbs. soil + 25 grams aluminum chloride. 4. 10 lbs. soil + 35 grams aluminum chloride.

Left to right: 1. Control—no treatment. 2. 10 lbs. soil + 5 grams sulphur. 3. 10 lbs. soil + 10 grams sulphur. 4. 10 lbs. soil + 20 grams sulphur. 5. 10 lbs. soil + 40 grams sulphur. 6. 10 lbs. soil + 60 grams sulphur.

Left to right: 1. Control—no treatment. 2. 10 lbs. soil + 5 grams ammonium sulphate. 3. 10 lbs. soil + 10 grams ammonium sulphate. 4. 10 lbs. soil + 20 grams ammonium sulphate. 5. 10 lbs. soil + 40 grams ammonium sulphate. 6. 10 lbs. soil + 60 grams ammonium sulphate.

Fig. 3

Nut grass—Red clay soil.

Fig. 4. Nut grass—red clay soil—second planting.
Left to right: 1. Control—no treatment. 2. 10 lbs. soil + 5 grams sulphur. 3. 10 lbs. soil + 10 grams sulphur. 4. 10 lbs. soil + 20 grams sulphur. 5. 10 lbs. soil + 40 grams sulphur. 6. 10 lbs. soil + 60 grams sulphur.

Sulphur: These pot experiments on the red clay type indicate that in the use of sulphur may lie a method for the control of nut grass. The first planting, as shown in Fig. 4, was made at the time the sulphur was applied, and even up to the completion of the experiment much of the sulphur was still undecomposed. Toxicity was shown in pot No. 4 of reaction pH 5.3 (approximately 4 tons sulphur per acre). It is probable that later toxicity would develop in pot No. 3 (2 tons per acre), as the acidity was still increasing at the end of the experiment and was just at the toxic point.

Ammonium Sulphate: The plants in the first set were slightly stunted in growth, probably due to the heavy applications of salt, as there was no great increase in acidity at the end of the first planting and still less at the end of the second planting. It is probable that the continued use of ammonium sulphate over a period of years would gradually increase the soil acidity sufficient to kill out the nut grass.

Aluminum Chloride: In the first planting there was some toxicity shown before the aluminum chloride had been fixed by the soil. In the second planting it was shown only in the heaviest application at pH 5.80.

The relation between soil reaction and plant distribution, such as we have observed with nut grass, is by no means a new subject. Wherry (1) has shown the distribution of a species may be limited in a very definite way by soil reaction. He has confined his studies mostly to the distribution of natural flora, but his observations cover quite extensive investigations. Similar studies have been conducted in England by Atkins (2) in which also a definite relationship is shown. Wherry does not contend that reaction is the only factor of importance or that the acid acts directly on the plant. As he states, some plants may require for themselves or for symbiotic organism a soil of definite reaction; others may be affected by some physical or chemical property of the soil which accompanies such reaction; and still other plants may be driven into soils of a certain degree of acidity by more vigorous species which monopolize neighboring soils of greater or less acidities.

Some practical applications of this property of plants are of interest. Gillespie and Hurst (3) have shown a difference in the adaptation of soil types to potato culture. On a soil of pH 5.2 potatoes grew free from scab. At pH 5.93 they were badly attacked by this disease. In this case we have a difference in biological characteristics with reaction range or an indirect effect of soil reaction on plant growth of great importance, however, in potato culture. To grow potatoes free from scab it is only necessary to control the soil reaction by fertilization.

Another fungus disease, "finger-and-toe," develops to a harmful extent only in acid soils and therefore acidity in this case is undesirable.

The blueberry thrives in soils so acid as to be worthless for ordinary agricultural purposes. Acidity also seems to be desirable for the cranberry and blackberry. The growth of leguminous plants is often affected in acid soils due to the lessened multiplication of the symbiotic nitrogen fixing bacteria.

More closely related to the growth of nut grass on acid soils is the work of the Rhode Island Experiment Station (4) in which they have studied the influence of different fertilizers on a number of grasses and mixtures for lawns, golf links and polo fields. These experiments, involving a number of grass plots, were started in 1905 and have now reached a point where by controlling soil reaction by varying the fertilizer practice they can definitely control not only the type of grass or clover but also assure freedom from many weeds. In other words, their experiments have yielded a method of weed control on lawns by fertilization. They have classified a number of grasses as follows: acid resistant, Awnless Brome, Red top, Rhode Island bent, Sweet Vernal, Tall meadow oat, Velvet grass; less resistant, Kentucky blue, Orchard, Meadow fox-tail, Sheep's fescue, Tall fescue, Timothy. This classification has been arrived at by planting mixtures in plots and applying residually acid, neutral and basic fertilizers for a period of 20 years.

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Oil Burning in Stationary Power Plants*

Steam and Mechanical Atomizing; Heating the Oil; Furnace Volume and Arrangement

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(From a Paper Presented Before the A. S. M. E. by Nathan E. Lewis)

For moderate sized plants and where the load is reasonably steady, so that the boilers are not called on for extreme overloads, the steam atomizer is used and has certain advantages. At rated load, it operates with moderate draft; it is simple and easy to keep in repair; oil to supply it can be at lower pressure and temperature than for mechanical atomizers, 130 to 190 deg. F. and 40 to 60 lbs. It gives, however, a long, flat flame which must have room so that it will not touch the furnace walls or boiler heating surface; its capacity is 1,200 to 1,300 lbs. of oil an hour per burner, the maximum capacity to which the boiler can be worked being 200 per cent of rating; furnace volume required is but 0.15 cu. ft. per sq. ft. of heating surface or 0.35 cu. ft. per lb. of oil to be burned per hour. Air supply is through a false floor of brick checker work, the pattern and arrangement of this checker work having considerable influence on the effectiveness of the operation. This makes use of more than one row of burners impossible.

Mechanical atomizers are generally used where a heavy overload is to be carried and maximum capacities are desired. The mechanical burner will operate a boiler at as high overload as a coal-fired furnace; it will burn 1,500 to 1,600 lbs. of oil an hour and can go higher, if sufficient draft and blast are furnished; it gives a short conical flame and can evaporate as much as 10 lbs. of steam per square foot of heating surface and as much as 60 lbs. per cu. ft. of furnace volume. On the other hand, the oil should be heated to 200 to 280 deg., which requires live steam, and the oil is handled at 100 to 250 lbs. pressure; also a higher draft must be furnished than for steam atomization. Furnace volume must be provided of 0.5 cu. ft. per sq. ft. of heating surface or 0.5 cu. ft. per lb. of oil to be burned an hour. The high temperatures resulting from high rate of combustion make the problem of furnace wall maintenance difficult. Air is supplied around the burner itself, the position of the impeller plate through which the air comes having a considerable effect on the efficiency of the burner, but allowing of the use of two rows of burners in a boiler, staggered vertically.

Oil Must Be Heated

In heating the oil, care should be taken that it is sufficient but not too great. Low temperature results in poor atomization and a smoky fire; too high temperature results in waste of steam, pulsations of the flame and a lowered capacity of the burner. With steam atomization, exhaust steam can be used for heating

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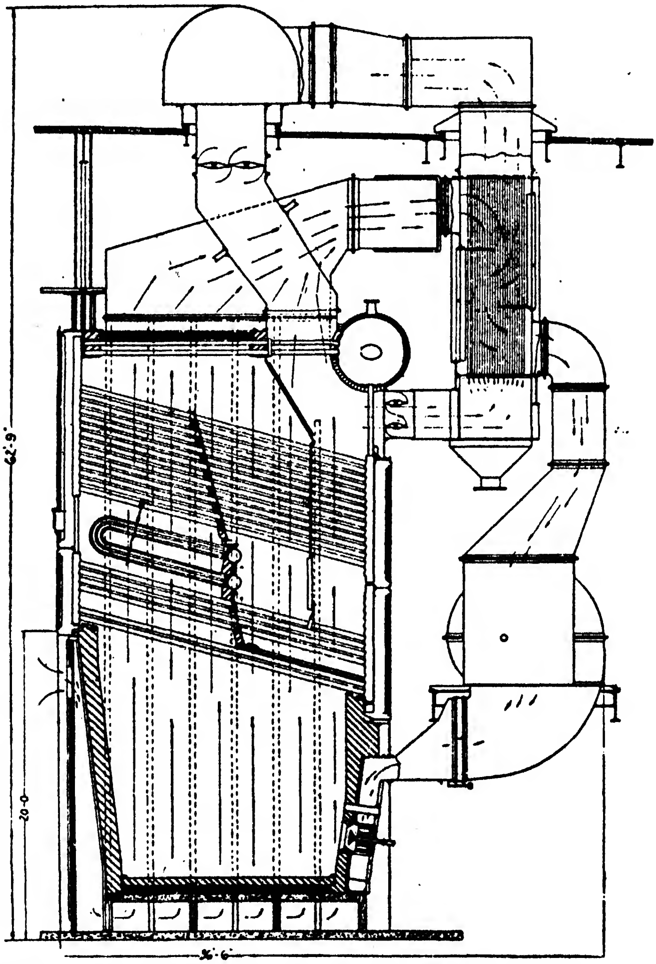
* Power Plant Engineering, Volume XXIX, No. 2.

the oil and the heating apparatus need be tested only for 150 lbs. on the oil side and 60 lbs. on the steam side; for mechanical atomization, live steam is necessary for heating and both oil and steam sides of the heater should be tested for 250 lbs. The heavier the oil used, the higher the temperature to which it must be heated to work satisfactorily.

Extreme care must be taken to get pipe lines carrying oil tight, as the oil is difficult to hold at the joints and a small leak may produce a big fire hazard. It is necessary, therefore, to have the piping of ample size, to use long-radius bends and to keep the number of joints down to the least possible, providing valves to isolate sections for repairs when needed.



In this installation, walls are cooled by air and this air is further heated for supply to the oil burners.

Because of the high temperatures carried in oil-burning furnaces, it is essential to have the best possible furnace walls and to cool them as much as possible. Two methods of cooling have been proposed and tried: air circulation in hollow walls and setting boiler tubes in the walls to carry away some of the heat. Even

then, the best quality of fire brick is needed which can be had only by careful selection, this, of course, resulting in higher cost, though the quality of fire brick is being improved by manufacturers in response to the demand. Most brick will undergo plastic deformation under 25 lbs. pressure per sq. in. and 2,400 deg. F. temperature, or under 10 lbs. pressure and 2,600 deg. As furnace brick is often under 15 lbs. pressure and furnace temperatures run as high as 3,000 deg., it is evident that only the best brick will serve. Small volumetric changes in the brick, due to expansion and shrinkage, will result in bulged and cracked walls and larger changes, in spalling.

One form of air cooling which has been tried is shown in the illustration. it is an installation made by the Babcock & Wilcox Company for the Houston (Tex.) Lighting and Power Company. Air from a point about 17 ft. above the boiler room floor is passed down through ducts back of the rear wall of the furnace and under the floor to ducts back of the side walls. It rises through these and a breeching to an air heater whence it is drawn by a fan and delivered to the oil burners. This unit has 19,884 sq. ft. of heating surface, 11,660 sq. ft. of air heating surface, rated capacity of 150,000 lbs. of steam an hour and evaporation, at rating, of 7½ lbs. of steam an hour per sq. ft. of heating surface. The experience with this type of cooling is encouraging but not sufficient to warrant definite statements as to its economy.

(W. E. S.)

Sugar Prices

96° Centrifugals for the Period June 19, 1925, to September 15, 1925

Date		Per Pound	Per Ton	Remarks
June	19, 1925	4.40¢	$88.00	Cubas.
"	23	4.385	87.70	Cubas, 4.40; Philippines, 4.37.
"	24	4.37	87.40	Cubas.
"	25	4.33	86.60	Cubas.
"	26	4.285	85.70	Porto Ricos, 4.30, 4.27.
July	1	4.30	86.00	Porto Ricos.
"	6	4.285	85.70	Cubas, 4.30, 4.27.
"	7	4.27	85.40	Philippines.
"	9	4.255	85.10	Cubas, 4.27; Porto Ricos, 4.24.
"	10	4.21	84.20	Porto Ricos.
"	14	4.24	84.80	Cubas.
"	15	4.27	85.40	Cubas.
"	23	4.265	85.30	Cubas, 4.27; Philippines, 4.26.
"	24	4.27	85.40	Cubas.
"	27	4.24	84.80	Porto Ricos.
"	29	4.255	85.10	Porto Ricos, 4.27; Cubas, 4.24.
"	30	4.30	86.00	Cubas.
Aug.	3	4.27	85.40	Cubas.
"	4	4.30	86.00	Porto Ricos.
"	5	4.33	86.60	Cubas.
"	6	4.37	87.40	Spot Cubas.
"	7	4.385	87.70	Cubas, 4.37, 4.40.
"	10	4.37	87.40	Cubas.
"	11	4.35	87.00	Spot Cubas, 4.37, 4.33.
"	12	4.30	86.00	Spot Cubas.
"	14	4.32	86.40	Spot Cubas, 4.31, 4.33.
"	18	4.37	87.40	Cubas.
"	19	4.385	87.70	Spot Cubas, 4.37; Cubas, 4.40.
"	20	4.37	87.40	Cubas.
"	21	4.33	86.60	Cubas.
"	24	4.385	87.70	Spot Cubas, 4.38, 4.39.
"	25	4.40	88.00	Cubas.
"	28	4.415	88.30	Spot Cubas, 4.43; Cubas, 4.40.
Sept.	2	4.37	87.40	Cubas.
"	3	4.325	86.50	Cubas, 4.33; Spot Cubas, 4.32.
"	9	4.33	86.60	Porto Ricos.
"	14	4.27	85.40	Philippines.
"	15	4.21	84.20	Cubas.